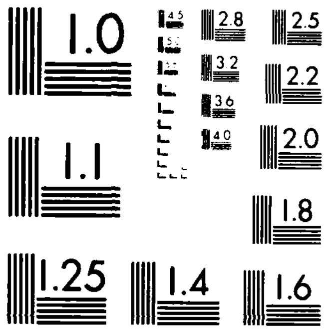
AD-A149 908 DEPLOYMENT AREA SELECTION AND LAND WITHDRAWAL/ACQUISITION M-X/MPS (M-X/MU.. (U) HENNINGSON DURHAM AND RICHARDSON SANTA BARBARA CA 02 OCT 81 1/5

UNCLASSIFIED M-X-ETR-17-VOL-2 F/G 6/3 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

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M-X/MPS

ENVIRONMENTAL

TECHNICAL REPORT

PRELIMINARY FEIS

REVIEW COPY 2 OCTOBER 1981

ETR 17

VOLUME II

PROTECTED SPECIES

DEPLOYMENT AREA SELECTION AND LAND WITHDRAWAL/ ACQUISITION

DEPARTMENT OF THE AIR FORCE

M-X ETR-17

PROTECTED SPECIES

Volume II

Prepared for

United States Air Force
Ballistic Missile Office
Norton Air Force Base, California

By	
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By

Henningson, Durham & Richardson, Inc.
Santa Barbara, California

REVIEW COPY OF WORK IN PROGRESS

2 October 1981

DEPARTMENT OF THE AIR FORCE
WASHINGTON 20330

OFFICE OF THE ASSISTANT SECRETARY

Federal, State and Local Agencies

On October 2, 1981, the President announced his decision to complete production of the M-X missile, but cancelled the M-X Multiple Protective Shelter (MPS) basing system. The Air Force was, at the time of these decisions, working to prepare a Final Environmental Impact Statement (FEIS) for the MPS site selection process. These efforts have been terminated and the Air Force no longer intends to file a FEIS for the MPS system. However, the attached preliminary FEIS captures the environmental data and analysis in the document that was nearing completion when the President decided to deploy the system in a different manner.

The preliminary FEIS and associated technical reports represent an intensive effort at resource planning and development that may be of significant value to state and local agencies involved in future planning efforts in the study area. Therefore, in response to requests for environmental technical data from the Congress, federal agencies and the states involved, we have published limited copies of the document for their use. Other interested parties may obtain copies by contacting:

National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Telephone: (703) 487-4650

Sincerely,

JAMES F. BOATRIGHT
Deputy Assistant Secretary
of the Air Force (Installations)

1 Attachment
Preliminary FEIS

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APPENDIX B-1

INTENSIVE AQUATIC BIOLOGICAL STUDIES IN NEVADA, 1980

ENVIRONMENTAL ANALYSIS OF FOUR AQUATIC HABITATS IN EAST-CENTRAL NEVADA JUNE-SEPTEMBER, 1980

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Interim Final Summary Report to HDR Sciences
(contract No. HDR/RPA15 Ext)

December, 1980

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CONCLUSIONS

1. Within the MX Missile System potential impact area (including the four aquatic study areas) a number of relict, endemic, sensitive, and endangered organisms occur.

2. Changes of flow regimes in aquatic habitats occupied by native species will result in depletion or extinction of these endemic species. This is true regardless of the cause of a change of flow regime, but could result from pumping of groundwater for either construction or operation of the MX Missile System.

3. Construction activities must be kept away from springs and their outflows to prevent direct impacts such as alteration of outflow channels or unintentional transfer of aquatic organisms.

4. The rate of introduction of detrimental exotic species, including fish and mollusks, will increase due to increased human activity within the area impacted by the MX Missile System.

5. The White River spinedace has been extirpated in Preston Big Spring, apparently as a result of directing the outflow into an underground tube some 500 meters downstream from the source.

6. The White River desert sucker has declined in abundance in Preston Big Spring, apparently as a result of the modifications mentioned in number 5 above.

7. Mitigation of the adverse impacts of the construction and operation of the MX Missile System, we believe, is only partially possible by development of large refuge areas of natural desert aquatic habitats and by development of a continuing and comprehensive public education program.

8. Mitigation measures must squarely address the problem of maintaining natural habitats as the only successful and permanent means of avoiding adverse impacts to native species. This may require establishing a refuge system of representative desert aquatic ecosystems in the deployment area.

9. Some mitigation of the adverse impacts certain to result from increased population may be possible through a continuous and comprehensive public education program which focuses on improving the general understanding of the ecological effects of, even seemingly minor, activities centered on desert aquatic systems.

10. Surveys of population status of mollusks, fish, invertebrates and other organisms should be undertaken throughout the deployment area.

ABSTRACT

To provide a data base on aquatic resources in eastern and central Nevada useable in developing objective estimates of the probable impacts of deployment of an MX missile system in Nevada, we examined four selected aquatic habitats in some detail and several others somewhat more superficially. Data were collected in June through September, 1980, at Preston Big Spring, Big Spring at Lockes Ranch, Shoshone Ponds, the outflow of Ash Spring and several other aquatic habitats in Spring Valley and Steptoe Valley. Information available through the literature, as well as unpublished data from J.E. Deacon's files, were used as additional sources of information. A large number of endemic, sensitive or endangered organisms occur within the area proposed for deployment of the MX Missile System. Several endemic, undescribed species and genera of mollusks were discovered in various springs in Spring Valley, Steptoe Valley, Railroad Valley and White River Valley. Endemic mollusks also occur in Pahranagat Valley. Populations of endemic snails were found to be high in habitats that were unmodified and that did not contain introduced fish or other snails such as *Melanoides tuberculatus*. Dewatering, channelizing, construction of cement-lined ditches, damming, and establishment of non-native species of fishes or mollusks, reduce populations of native fishes and snails to varying degrees. Severe impacts on the native fishes and mollusks can be expected as a result of increased intensity of recreational use. This in turn will result in greatly increased probability of introduction of *Melanoides tuberculatus*, an oriental snail that almost entirely eliminates many native snails, as well as a variety of tropical fishes that adversely affect native fishes.

Preston Big Spring was the most modified of any system studied and showed a major reduction of aquatic habitat due to underground diversions some 400 meters below the spring source. The channel also had been dredged in the past and old diversion channels and weirs could still be discerned. At this spring, the invertebrate fauna was the most diverse of any system studied. This is partly attributable to the cooler waters present in this habitat. This spring also had diverse algal and aquatic macrophyte communities providing a rich source of microhabitats to support a variety of invertebrate species. This spring historically contained four native species of fish but our study demonstrated that the White River spinedace disappeared subsequent to 1966-67. The White River sucker population was found to be scarce and is in danger of becoming extirpated if further habitat alterations continue. White River speckled dace and White River springfish were the dominant fish species in this habitat. The dace was the most abundant and was primarily carnivorous, while the springfish was herbivorous.

Lockes Ranch was the warmest of all habitats studied and contained relatively few species of alga and aquatic macrophytes. No change in the species composition or distribution of fishes could be discerned during the course of the field work. No major modifications to this habitat, in the immediate vicinity of the spring source, could be discerned. The nitrogen-poor waters provide a selective advantage to nitrogen-fixing algae, which form the base of the food net. *Rivularia* sp. appears to provide an ostracod nursery algal mat, which cannot be penetrated by fish predators. The Railroad Valley springfish was primarily carnivorous. Fish population densities throughout the spring and marsh system probably are

strongly influenced by winter temperature.

Shoshone North Pond was the only habitat studied that was man-made and maintained. It currently supports an introduced population of Pahrump killifish from Manse Ranch, Pahrump Valley, Nye County, Nevada. The pond is approximately 4 meters across and 1.5 meters deep. It supports a small stand of aquatic macrophytes and an extensive mat of filamentous algae. Invertebrate prey populations are primarily confined to the algal mats and shallow areas of the shore, where fish cannot prey upon them. Historical data collected at Manse Ranch suggests that killifish are primarily carnivorous. They probably strongly influence the density and distribution of zooplankton, snails, chironomids and other invertebrates within this habitat.

The outflow of Ash Spring, on the Burns Ranch, was modified relatively little by man. There is not a well-defined aquatic macrophyte zone along the outflow. The shoreline is predominately vegetated by willow, ash, grape and several other riparian species. The algal community in this system was fairly diverse and showed some fluctuations over the study period. The invertebrate fauna was almost entirely dominated by the introduced oriental snail, Melanoides tuberculatus. The native fish fauna showed a strong preference for similar type habitats. The speckled dace were almost exclusively found in deep portions of the habitat, behind small snags, while adult Pahranagat roundtail chub were only found in a deep hole at transect 50. The presence of young roundtail chub throughout the habitat suggests that there is a shift in habitat requirements in the adult population. The convict cichlid and mexican molly shared dominance in the fish fauna. Clearly, the non-native fish and the introduced snail, Melanoides tuberculatus, have caused a reduction in population densities of native fishes and mollusks. Other invertebrates may also have been adversely affected.

Construction activities that involve use of, or even temporary manipulation of waters in Nevada, will profoundly affect the aquatic habitats in a variety of ways. Modifications of flow patterns or manipulation of waters has been shown to sometimes result in elimination of some endemic species of aquatic organism in Nevada. The secondary impacts resulting from increased recreational use of aquatic habitats will also adversely affect the endemic biota. Most notably, the intentional or unintentional spreading of non-native biota, which accompanies increased recreational use, will have profound and lasting impacts on Nevada's native aquatic biota.

INTRODUCTION

Four aquatic habitats in Nevada have been selected for intensive study in an effort to provide a data base that will allow objective estimates of probable impacts on the aquatic biota within the proposed area for deployment of an M X Missile System in Nevada. This report summarizes information developed as a result of field work in June, July, August, and September, 1980, at Preston Big Spring in White River Valley, Lockes Ranch in Railroad Valley, Shoshone Ponds in Spring Valley, and in the outflow of Ash Spring in Pahranagat Valley. These aquatic habitats were selected as being representative of the kinds of aquatic habitats in the deployment area. Studies conducted in these four habitats are intended to identify the kinds of environmental considerations that will be important in the deployment area once specific sites and specific impacts are identified. It is clear that each locality has its unique characteristics and that, therefore, it will be necessary to conduct site specific investigations as potential impacts are identified. This study serves both to identify the kinds of environmental problems existing in, or associated with, aquatic habitats in the proposed deployment area and as an example of the kind of site specific investigations that will be necessary. A brief survey of other aquatic habitats in Spring Valley provides considerable insight into the need for surveys of population status of at least molluscs throughout the deployment area. Other information for other valleys demonstrates a similar need with respect to fish population status. We have emphasized development of information pertinent to an assessment of the biological relationships of the fish populations in the four habitats studied.

The report includes a physical description of the four areas intensively sampled, information on certain physical and chemical characteristics of the water, data on occurrence, distribution and abundance of plants and animals in each of the four habitats, and information on food habits and population sizes of the fish populations. In addition, results of a molluscan survey of aquatic habitats in Spring Valley are included. Appendix A provides site specific information regarding occurrence and status of sensitive species of animals at many other localities within the deployment area. While this information is not complete, it does provide site specific information available to us at present beyond the four habitats intensively sampled.

Habitat Morphometry

Methods

Permanent controls were established at all the sample sites by placing paired stakes at the beginning and end of each 100 meter section of habitat. Transect lines at five meter intervals were then measured and marked with wooden stakes set perpendicular to the stream channel. A transit was used to record the angle and horizontal distance to each paired stake. Surveyors twine was then stretched between stakes at each transect and the horizontal distance of the riparian zone, aquatic macrophytes, and open water was recorded. Species composition and abundance was noted for each vegetation zone. Depth, current, and substrate data were taken at the edges of the aquatic macrophyte beds and at the point of highest current speed. Tables and figures for this section can be found in Appendix B at the end of the report.

Results And Discussion

Preston Big Spring

U T M (666,282 m E / 4,310,385 m N; Lund 2 Sheet)

Figure B-1 outlines the distributional patterns of the riparian and aquatic vegetation zones within the study area. Transect lines have been designated and are synonomous with station locations for all aquatic biological sampling conducted during June through September. The species composition of the plant community is given in Table B-1. Estimated percent coverage for each species at each transect location is provided in Table B-2.

The riparian zone along the western margin of the spring is easily divided into discrete zones based upon dominance within the plant community. From the spring source down gradient to transect 20 there is little true riparian vegetation. Open soil is prevalent with Asteraceae comprising 50-90% of the total species composition. From transect 20 down to transect 90 Salix sp.dominates the flora. Some Potentilla anserina (rose) is interspersed through transects 25 to 55, but does not contribute a major component to the overall community. Below transect 90, where thistle and rush dominate the ground cover, there is no true riparian zone.

The eastern boundary of the spring has a more diverse riparian flora that is heterogeneous in its distribution. The upper segments of the spring near its source down through transect 45 is composed primarily of Potentilla anserina and an assemblage of miscellaneous species that contribute almost half of the total cover. This component is primarily of Juncus, sage, thistle, mint, milkweed, willow-herb, and several species of Schrophulariaceae. The remainder of the habitat contains the above species except that the rose is lacking.

The riparian zone remained unchanged in both species composition and abundance during June, July and August. However, in the week preceeding September 5th, the riparian zone was severely trampled and grazed by cattle (Photos B 1-2). The only plant species to survive were willow, rose and Palmer's Penstemon. All other species were either trampled or grazed to ground level.

From June through August, the aquatic vegetation zone throughout the entire study area was dominated by two species: Rorippa nasturtium-aquaticum (watercress) and Scirpus americanus. Composition within a given transect was variable, though Scirpus comprised the majority of the biomass. Watercress reached its highest density in the head pool region and at transects 65a-65b, where a small spring source contributes additional flow to the system. In general, the western margin of the spring from the head pool to transect 65 contained well developed areas of aquatic macrophyte beds. These beds were also heavily grazed by the cattle and disturbance of substrates throughout the spring was obvious. This damage to both the riparian zone and aquatic macrophytes occurred from the spring source all the way down to the diversion weir.

Channel development at Preston Big Spring can be observed by reviewing Figures B-2 through 4. These also demonstrate the depth profiles along each transect line and the relative lateral extension of the aquatic vegetation zones. Table B-3 gives depth, current, and substrate readings associated with each transect for the respective vegetation zones and mid-channel for the June collections. There was no significant change in any of these parameters during July through September.

Preston Big Spring has experienced extensive modifications in the past. There is ample evidence of excavation along the entire outflow down to the point of underground diversion approximately 500 meters south of the spring source. This structure has resulted in the loss of the available aquatic habitat below that point. A few meters below transect 100 on the eastern bank is the remains of an old cement diversion weir. A recognizable channel can be discerned leading away to the south-east. No other historical above ground diversion channels could be discerned. Local testimony collected during the June sampling trip indicated that occasionally the spring is "drag-lined" to remove the watercress, and other nuisance plants. The extent of habitat modification, as a direct result of this activity, is at present unknown. Much of the spring outflow above transect 65 can be characterized by slight to moderate flows with extensive quiet water refugia provided by thick aquatic macrophyte beds along the western bank. The eastern bank does not possess this extensive aquatic macrophyte development, though it is present along its entire margin. Below transect 65, the outflow gradient steepens and the channel becomes very narrow with firm gravel and rock substrates and moderate to swift current velocities. The aquatic vegetation in this area is almost entirely Scirpus on both sides of the bank.

Lockes Ranch

U T M (607,194 m E / 4,268,020 m N; Nevada Quadrangle -4)

Figure B-5 outlines the distributional patterns of the aquatic and riparian vegetation zones for this study area. Transect lines have been designated and are synonomous with station locations. Photo B-3 provides a view of the spring pool looking south down the outflow. Those species identified within the various vegetation zones are presented in Table B-1.

Scirpus sp. comprised over 98% of the total cover in the aquatic macrophyte zone for the entire spring outflow. The remaining 2% was represented by Juncus and an assortment of species from the "riparian zone."

There was no true development of a riparian zone at Lockes Ranch. The study area was situated on a broad plateau approximately 450 meters wide that contained 4 genera in the Asteraceae, with Cirisium mohavense (thistle) and Anemopsis californica dominating the ground cover. The other species listed in Table B-1 were randomly interspersed throughout the "meadow" and comprised approximately 20% of the total abundance. There was no change in either composition or abundance during the study and these communities are considered to be very stable in the absence of external modifications.

Channel development at Lockes Ranch can be seen in Figures B-6 and 7. The spring pool is over 1.5 meters deep in some areas and tapers to a narrow outflow with depths generally decreasing down gradient. Current speeds are negligible in much of the spring pool but increase down gradient. Table B-4 gives specific depth, current, and substrate readings for each transect along the study area for the June collections. There was no significant change in either depth or current during the study. Substrates are generally very soft mud in the spring pool and immediate outflow and show a steady increase in firmness as current speeds increase. Substrates are primarily of travertine derivation with some organic debris. The carbonate crust that existed in the swifter portions of the outflow was disturbed sometime prior to the August sampling though large chunks still persisted throughout the study area. There is a lack of extensive shallow areas over much of the habitat until near transects 90 and 95. At this point there are some broad shelves along the eastern margin of the spring outflow. A major man-made structural diversion exists at transect 100, dividing the stream into two channels. One branch runs westward across Highway 6 and, eventually arcs west and south to irrigate wet meadows used for grazing by the Nevada Cattle Company. The other branch runs southward directly to the meadows just mentioned. A small underground siphon exists near transect 70 that feeds a small 6 inch diameter pipe leading to the south. Its purpose is unknown. The only other evidence of habitat alteration is the presence of an old "bath house" that sits across the stream at transects 75-80. There is no evidence that the stream course above transect 100 or the main pool itself have ever been excavated.

Shoshone North Pond

U T M (724,203 m E / 4,311,730 m N; Nevada Quadrangle 7-1)

Figure B-8 shows the basic habitat morphometry of Shoshone North Pond. Transect lines have been indicated to facilitate interpretation of the 3 cross-sectional transects provided in Figure B-9. Table B-5 shows the associated depth readings taken at each transect. There were no detectable current speeds within the pond and the substrates consisted of detrital mud and gravel. There was no riparian zone at this sample site and a poorly developed aquatic marcrophyte stand along the eastern and southern boundaries as seen in Photo B-4. The dominant emergent species was Scirpus, which comprised 98% of the total cover. Those species listed in Table B-1 comprised the remaining 2% and were found primarily along the northern and western boundary of the pond.

This pond exists within an artificial enclosure and is one of three nearly identical ponds that were constructed by the Bureau of Land Management as refugia for native fish species. Management control is under the jurisdiction of the Ely District Office.

Outflow Of Ash Spring

U T M (660,066 m E / 4,145,326 m N; Nevada Quadrangle 10-3)

Figure B-10 details the habitat morphometry data collected at this sampling site. The riparian zone is well developed within the study area, where ash dominates the stream boundaries. Interspersed with the ash is *Vitis californica*, the " California wild grape, " which is quite dense along the western shoreline at transect 50. There are also a few scattered species of cottonwood and domesticated olive trees throughout the habitat. There is no aquatic vegetation zone at this sampling site. Plants common to the surrounding meadow are distributed up to the shoreline and constitute a fairly uniform community. Dominant species are *Hydrocotyle* spp. (marshy pennywort); *Anemopsis californica* (yerba-mansa); *Eleocharis parishii* (spike rush); *Juncus* (common rush); and *Distichlis spicata* (salt grass). The western side of the stream channel is not heavily grazed and is considerably more lush than the eastern meadows, as Photo B-5 demonstrates. Table B-1 gives the specific plants collected at this locality. There was no detectable change in plant composition at this sampling site during the course of our field work.

Transect data for depth, current, and substrates can be found in Table B-6. Data is presented for June only as more detailed analysis are forthcoming from current studies utilizing the Instream Flow Methodology developed by the U. S. Fish and Wildlife Service. Substrates are primarily a function of current speed with firm sand bottoms occurring where current speeds are highest. Soft mud can be found along all the margins of the stream where current speeds are low or negligible. Figures B-11 through 13 show channel development through the study area. The eastern boundary, in general, contains most of the shallow, quiet water habitats that become exposed when irrigation diversions are made upstream. A deep hole and undercut bank on the eastern edge of the stream occur at transect 50. The western margin of the stream contains swift water and undercut banks. Only at transects 20 through 35 is there any shallow lateral development of quiet water habitat on the western edge of the stream.

PHYSICAL CHEMICAL CONDITIONS

METHODS

Standard methods were used for the collection and analysis of physical chemical data (Table 1). Methods of analysis are presented in U. S. A P H A (1975), except for nitrate, which has been described by Kellar et al. (1980). All samples for laboratory analysis, except nitrate samples, were collected and cooled to zero degrees C immediately following collection and maintained at this temperature until analysis. Nitrate samples were frozen immediately following collection and maintained in the frozen state until analysis. The following brands of electronic instruments were used for sample analysis:

Beckman Conductivity Bridge No. R C - 19

Instruments Lab, Inc. Portamatic pH Meter

Monitek Nephelometer - Model 21

Yellow Springs Instrument Oxygen Meter - Model No. 57

RESULTS

The following difficulties were encountered with the physical/chemical measurements:

(1) The oxygen meter developed technical difficulty in June and July, rendering questionable a significant amount of data. Only data for which the meter had been calibrated by Winkler test with no electronic drift in the meter output are presented for these months (Table 2 - all oxygen readings).

(2) Sulfate samples from June were improperly fixed in the field. As a result, analysis of water samples for sulfate from that sampling period could not be validated. Since all other related parameters were quite consistent between sampling periods for any given spring, very little difference was likely to have existed between June and July values.

(3) The pH meter developed technical difficulty in September so that no pH or alkalinity values were obtained.

There were considerable differences between aquatic systems in physical chemistry (Tables 2 and 3). In general, all the systems, except Shoshone North Pond, would be considered hard water springs with generally low salt content and some sulfate (Hem, 1970). Shoshone North

TABLE 1. Physical chemical methods used for various parameters measured during the study.

Parameter	Measurement	Method
Field Analyzed		
Oxygen	mg/l	O_2 meter or Winkler-Azide modification
Temperature	°C	Thermometer
pH	mg/l	EDTA Titrimetric
Hardness	mg/l	Potentiometric to pH 4.5
Laboratory Analyzed		
Nitrates (NO_3)	µg/l	Kellar et al. 1980
Sulfates	mg/l	Turbidimetric
Specific Conductance	µmhos/cm	Conductivity Bridge
Turbidity	N.T.U.	Nephelometric

TABLE 2. Field determined physical/chemical parameters.

Spring	Transect	Time	Dissolved O_2 Dup 1	Dissolved O_2 Dup 2	Temperature Dup 1	Temperature Dup 2	pH Dup 1	pH Dup 2	Hardness Dup 1	Hardness Dup 2	Alkalinity Dup 1	Alkalinity Dup 2
<u>June Sampling</u>												
Preston	100-2.1	0950	3.7	3.7	21.0	21.0	7.55	7.55	192	196	118	120
Preston	20-5.6	0900	3.2	3.1	21.0	21.0	7.50	7.50	192	196	116	116
Lockes	100-4.5	1600	3.2	3.2	37.0	37.0	7.20	7.20	248	248	237	233
Lockes	15-2.0	1455	1.6	1.7	37.2	37.2	7.20	7.20	248	252	232	232
Shoshone	surface	1600	9.7	9.6	26.5	26.5	9.35	9.35	52	53	52	52
Shoshone	0.25m	1600	6.6	6.6	25.5	25.5	-	-	-	-	-	-
Shoshone	0.50m	1600	6.3	6.3	25.5	25.5	-	-	-	-	-	-
Shoshone	0.75m	1600	6.0	6.0	25.5	25.5	-	-	-	-	-	-
Shoshone	surface	1735	10.0	10.0	26.0	26.0	8.60	8.60	52	52	52	51
Shoshone	0.25m	1735	7.0	7.0	25.5	25.5	-	-	-	-	-	-
Shoshone	0.50m	1735	6.7	6.7	25.5	25.5	-	-	-	-	-	-
Shoshone	0.75m	1735	6.7	6.7	25.5	25.5	-	-	-	-	-	-
Shoshone	1.00m	1735	6.6	6.6	25.5	25.5	-	-	-	-	-	-
Ash	50-5.8	1535	5.9	5.9	30.5	30.5	8.10	8.10	200	200	170	169
Ash	50-5.8	1540	5.8	5.9	30.5	30.5	8.10	8.10	200	200	168	167
<u>July Sampling</u>												
Preston	100-2.1	1030	3.2	3.2	21.8	21.8	7.72	7.74	206	208	117	116
Preston	20-2.1	1040	2.7	2.7	21.5	21.5	7.75	7.78	208	208	115	116
Lockes	100-4.5	1245	4.6	4.6	38.0	38.0	7.15	7.12	244	248	234	233
Lockes	15-2.0	1250	2.2	2.2	38.3	38.3	6.92	6.92	244	244	231	232
Lockes	100-4.5	2250	2.3	2.3	36.5	36.5	-	-	-	-	-	-
Lockes	15-2.0	2258	2.0	2.0	38.0	38.0	-	-	-	-	-	-
Shoshone	surface	1400	12.0	12.0	27.0	27.0	8.50	8.50	52	52	55	55
Shoshone	surface	1410	12.1	12.0	27.0	27.1	8.50	8.50	52	52	54	55
Shoshone	surface	1500	10.2	10.2	27.2	27.2	-	-	-	-	-	-

- = no observation made.

(continued)

TABLE 2. (Continued)

Spring	Transect	Time	Dissolved O_2 Dup 1	Dissolved O_2 Dup 2	Temperature Dup 1	Temperature Dup 2	pH Dup 1	pH Dup 2	Hardness Dup 1	Hardness Dup 2	Alkalinity Dup 1	Alkalinity Dup 2
July Sampling (Cont.)												
Shoshone	surface	1600	9.3	9.4	27.2	27.2	-	-	-	-	-	-
Shoshone	surface	1700	9.5	9.8	27.0	27.0	8.75	8.75	-	-	-	-
Shoshone	surface	1800	10.8	10.9	26.6	26.6	8.80	8.80	-	-	-	-
Shoshone	surface	1900	9.6	9.4	25.5	25.4	8.40	8.40	-	-	-	-
Shoshone	surface	2000	9.4	9.4	25.0	25.0	8.26	8.28	-	-	-	-
Shoshone	surface	0615	5.1	5.1	21.2	21.2	-	-	-	-	-	-
Ash	50-5.8	1445	6.0	6.0	31.5	31.5	8.05	8.05	188	192	163	160
Ash	50-5.8	1545	6.0	6.0	31.5	31.5	8.05	8.00	188	188	160	160
August Sampling												
Preston	95-2.1	1000	5.0	5.0	21.5	21.5	7.70	7.70	200	204	115	115
Preston	20-5.8	1010	4.6	4.6	21.5	21.5	7.80	7.79	204	204	117	118
Preston	95-2.1	1600	4.6	4.6	21.9	21.9	7.75	7.75	-	-	-	-
Preston	20-5.8	1605	4.2	4.2	21.5	21.5	7.80	7.80	-	-	-	-
Preston	95-2.1	0515	3.4	3.4	21.5	21.5	-	-	-	-	-	-
Preston	20-5.8	0520	3.2	3.2	21.5	21.5	-	-	-	-	-	-
Lockes	100-4.5	1145	4.7	4.7	38.2	38.2	7.30	7.30	280	280	229	230
Lockes	15-2.0	1155	2.2	2.2	38.6	38.6	7.10	7.10	276	276	229	230
Lockes	100-4.5	1650	3.0	3.0	38.3	38.3	-	-	-	-	-	-
Lockes	15-2.0	1700	1.8	1.8	38.8	38.8	-	-	-	-	-	-
Lockes	100-4.5	0520	2.4	2.4	36.5	36.5	-	-	-	-	-	-
Lockes	15-2.0	0525	1.8	1.8	38.0	38.0	-	-	-	-	-	-
Shoshone	1-6	1250	9.2	9.2	26.8	26.8	8.75	8.80	64	60	53	54
Shoshone	10-5	1300	9.2	9.2	26.5	26.7	8.70	8.75	60	60	54	54
Shoshone	1-6	1700	10.8	10.7	27.8	27.8	-	-	-	-	-	-
Shoshone	10-5	1705	10.8	10.8	27.7	27.8	-	-	-	-	-	-
Shoshone	1-6	0530	5.6	5.6	24.0	24.0	-	-	-	-	-	-
Shoshone	10-5	0532	5.5	5.5	24.0	24.0	-	-	-	-	-	-

- = no observation made.

(continued)

TABLE 2. (Continued)

Spring	Transect	Time	Dissolved O_2 Dup 1	Dissolved O_2 Dup 2	Temperature Dup 1	Temperature Dup 2	pH Dup 1	pH Dup 2	Hardness Dup 1	Hardness Dup 2	Alkalinity Dup 1	Alkalinity Dup 2
<u>August Sampling (Cont.)</u>												
Ash	50-5.8	1045	6.4	6.4	29.1	29.1	8.2	8.2	232	234	168.0	169.0
Ash	50-5.8	1500	6.3	6.3	30.5	30.5	8.2	8.3	234	234	168.0	170.0
<u>September Sampling</u>												
Preston	95-2.3	1020	4.6	4.6	21.8	21.8	-	-	188	184	-	-
Preston	20-5.8	1025	4.1	4.0	22.0	22.0	-	-	184	184	-	-
Preston	95-2.3	1400	4.2	4.2	21.8	21.8	-	-	-	-	-	-
Preston	20-5.8	1405	4.1	4.0	22.0	22.0	-	-	-	-	-	-
Preston	95-2.3	0615	3.0	3.0	21.5	21.5	-	-	-	-	-	-
Preston	20-5.8	0615	2.8	2.7	21.0	21.0	-	-	-	-	-	-
Lockes	100-4.5	1020	2.9	2.9	36.0	36.0	-	-	240	240	-	-
Lockes	20-2.0	1025	2.1	2.1	37.0	38.0	-	-	240	236	-	-
Lockes	100-4.5	1515	3.9	3.9	36.0	36.0	-	-	-	-	-	-
Lockes	20-2.0	1520	2.2	2.1	37.0	37.0	-	-	-	-	-	-
Lockes	005-1.0	1525	1.4	1.4	38.0	38.0	-	-	-	-	-	-
Lockes	000-2.0	1530	1.6	1.5	38.1	38.1	-	-	-	-	-	-
Lockes	100-4.5	1800	2.3	2.3	35.8	35.8	-	-	-	-	-	-
Lockes	20-2.0	1800	1.6	1.6	37.0	37.0	-	-	-	-	-	-
Lockes	100-4.5	0545	2.5	2.5	35.0	35.0	-	-	-	-	-	-
Lockes	20-2.0	0550	1.7	1.7	36.0	36.0	-	-	-	-	-	-
Shoshone	surface	1045	8.2	8.2	22.0	22.0	-	-	60	64	-	-
Shoshone	0.25m	1045	7.8	7.8	21.5	21.5	-	-	-	-	-	-
Shoshone	0.5Cm	1045	12.0	12.0	21.0	21.0	-	-	-	-	-	-
Shoshone	surface	1330	9.5	9.5	25.0	25.0	-	-	56	60	-	-
Shoshone	0.25m	1330	10.0	10.0	22.5	22.5	-	-	-	-	-	-
Shoshone	0.50m	1330	12.5	12.5	22.0	22.0	-	-	-	-	-	-
Shoshone	surface	1630	19.4	19.4	25.0	25.0	-	-	-	-	-	-
Shoshone	0.25m	1630	11.5	11.5	24.6	24.6	-	-	-	-	-	-
Shoshone	0.50m	1630	11.3	11.3	24.0	24.0	-	-	-	-	-	-

- = no observation made.

(continued)

TABLE 2. (Continued)

Spring	Transect	Time	Dissolved O_2 Dup 1	Dissolved O_2 Dup 2	Temperature Dup 1	Temperature Dup 2	pH Dup 1	pH Dup 2	Hardness Dup 1	Hardness Dup 2	Alkalinity Dup 1	Alkalinity Dup 2
September Sampling (Cont.)												
Ash	50-5.8	0900	6.4	6.4	28.3	28.3	-	-	184	188	-	-
Ash	50.5.8	1000	6.4	6.4	27.8	27.8	-	-	188	184	-	-

- = no observation made.

TABLE 3. Laboratory analyzed physical/chemical parameters.

Spring	Transect	Time	Nitrates Dup 1	Nitrates Dup 2	Sulfates Dup 1	Sulfates Dup 2	Specific Cond. Dup 1	Specific Cond. Dup 2	Turbidity Dup 1	Turbidity Dup 2
June Sampling										
Preston	20-5.6	0900	550.0	-	*	*	424.1	423.1	0.30	0.31
Preston	100-2.1	0950	370.0	360.0	*	*	423.6	423.0	0.34	0.31
Lockes	15-2.0	1455	14.5	-	*	*	706.0	706.8	1.01	0.95
Lockes	100-4.5	1450	14.5	-	*	*	714.6	714.0	0.45	0.50
Shoshone	1-6	1600	27.5	-	*	*	149.8	149.8	0.75	0.78
Shoshone	10-5	1735	46.5	-	*	*	147.5	147.6	0.80	0.75
Ash	50-5.8	1535	113.0	-	*	*	499.2	498.6	1.20	1.27
Ash	50-5.8	1540	158.5	-	*	*	499.2	499.2	1.02	0.99
July Sampling										
Preston	20-2.1	1030	622.0	632.0	50.5	51.9	419.6	416.2	0.28	0.32
Preston	100-2.1	1040	702.0	690.0	40.8	39.0	418.4	423.3	0.37	0.31
Lockes	15-2.0	1245	und	und	48.0	43.2	693.5	698.2	1.36	1.50
Lockes	100-4.5	1250	und	und	44.0	48.0	696.6	701.2	0.39	0.51
Shoshone	1-6	1400	28.0	27.0	0.7	2.4	152.3	155.3	1.07	0.72
Shoshone	10-5	1410	29.0	28.0	1.6	0.0	152.3	152.6	0.77	0.80
Ash	50-5.8	1545	144.0	145.0	37.4	39.4	468.2	471.8	1.21	1.17
Ash	50-5.8	1445	103.0	104.0	35.0	38.6	471.4	473.4	1.02	1.00
August Sampling										
Preston	20-2.1	0820	682.5	-	42.0	39.4	417.1	417.0	0.73	0.07
Preston	100-2.1	0800	670.5	-	41.8	44.0	414.6	415.0	0.26	0.25
Lockes	15-2.0	1110	und	-	43.2	50.4	692.5	692.0	0.38	0.44
Lockes	100-4.5	1050	und	-	43.2	40.0	689.6	690.8	0.46	0.48
Shoshone	1-6	1225	26.5	-	3.0	0.0	149.1	149.2	1.35	1.44
Shoshone	10-5	1230	26.5	-	0.0	0.0	14.9	148.9	1.48	1.41
Ash	50-5.8	1110	140.8	-	40.4	39.4	496.0	497.1	1.02	0.96
Ash	50-5.8	1100	131.5	-	39.4	42.0	493.7	495.3	0.87	0.87

* - samples were improperly fixed in the field.
\- - no observations were made.
und - undectable.

(continued)

TABLE 3. continued.

Spring	Transect	Time	Nitrates Dup 1	Nitrates Dup 2	Sulfates Dup 1	Sulfates Dup 2	Specific Cond. Dup 1	Specific Cond. Dup 2	Turbidity Dup 1	Turbidity Dup 2
<u>September Sampling</u>										
Preston	20m	0815	615.0	-	42.0	43.2	410.4	410.1	0.56	0.50
Preston	100m	0800	655.0	-	36.8	39.2	409.8	410.2	0.49	0.52
Lockes	15m	0930	und	-	50.0	46.8	685	685.7	0.30	0.28
Lockes	100m	1010	22.0	-	52.0	52.8	686.3	686.6	0.40	0.38
Shoshone	3-5	1045	45.0	-	0.0	0.3	155.0	159.6	0.60	0.61
Shoshone	3-10	1055	20.0	-	0.0	0.0	149.9	150.8	0.59	0.64
Ash	4-50-5.8-2	0900	123.5	-	32.0	34.0	483.0	485.9	1.47	1.48
Ash	4-50-5.8-1	0910	102.0	-	36.0	34.0	486.5	486.7	1.40	1.41

* = samples were improperly fixed in the field.
- = no observations were made.
und = undectable.

Pond was quite low in dissolved solids. None of the springs displayed turbidity to any degree. Lockes Ranch Spring and Shoshone North Pond were quite low in nitrates, while the outflow of Ash Spring and particularly Preston Big Spring were much higher.

The pH of all the springs was in the alkaline range but not excessive in any spring. The pH at Shoshone North Pond was quite variable, undoubtedly a result of daily algal productivity cycles.

Oxygen levels at Shoshone North Pond were generally high. Oxygen at the surface at Shoshone North Pond was supersaturated during the peak illumination period, but never dropped below 50% saturation even when measured just before sunrise. Although the absolute values of some June and July oxygen readings with the meter were questionable, the relative pattern of oxygen content with depth at Shoshone North Pond indicated a nearly homogeneous oxygen profile,with the exception that a drastic peak existed at the surface during maximum light intensity. There were indications that the oxygen levels became homogenous throughout the pond overnight except during September, when there was an oxygen peak at the bottom of the pond. This anomaly is explained by the fact that upon arrival at Shoshone Ponds in September, it was observed that the algae mat was lying on the bottom of the north pond. The oxygen peak shifted to the surface later in the day as the algae mat slowly floated to the surface as a result of photosynthetic oxygen production.

The oxygen levels at Preston Big Spring and Lockes Ranch Spring were low, generally below 50% saturation. Oxygen levels did exceed 50% saturation at Lockes Ranch Spring at the 100 meter transect in July at 1200 hours, even though the absolute oxygen content was quite low. The solubility of oxygen in Lockes Spring is low however, creating a low oxygen condition especially near the head pool. During high light intensity periods there was a notable difference in oxygen content near the head pool and 100 meters downstream at Lockes Ranch Spring , although oxygen levels throughout the study area tended to equalize overnight (Table 2). Although there were some indications of diurnal differences, the oxygen content of the water at both ends of the study area at Preston Big Spring displayed only slight differences at any given time.

Oxygen levels were quite constant throughout the four month study period in all aquatic ecosystems studied. There were indications in the data that oxygen production and temperature increased slightly as a function of day length. Throughout the four month period, physical chemical parameters were not causing excessive stress on the biota of the sample sites. Only conditions at Lockes Ranch Spring present borderline natural stressful conditions. The ecological relationships of extremely low nitrates at Lockes Ranch Spring and variable high nitrates at Preston Big Spring is not well understood at this time. Winter and early spring physical chemical conditions need to be monitored before seasonal fluctuations can be ascertained.

ALGAL COMMUNITIES

INTRODUCTION

" Aufwuchs " is a term used to designate the microcommunity associated with substrates in aquatic habitats. It includes attached algae and organisms that live intermingled within it. In this study the algal component of the "aufwuchs" community was examined. The purpose of this section is to list the algal species found in each habitat and to describe their position in the community. Literature describing algae of the study habitats is quite limited. La Rivers (1978) is the only source with specific reference to any of the study habitats. He described six species of algae found in Lockes Ranch Spring during 1956-57. La Rivers' book (1978) is the best source for distributions, descriptions, and illustrations of algae found in Nevada springs. The book is a compilation of his findings and information in a handful of published reports on Nevada algae (Drouet ; La Rivers 1965; and Shields and Drouet 1962). He describes more than 450 species of algae from the western Great Basin. Not mentioned by La Rivers is an unpublished master thesis by (Morgan, 1962) listing 31 species, mostly blue-green algae, which were previously unrecorded in Death Valley. Later, Taylor (1979) reported on 52 species of algae from eight natural springs on the Nevada Test Site. Thirteen species (mostly diatoms) were common to Taylor's study and the present one. The Nevada Test Site springs had very low flow rates; some reportedly dry up for short periods during the year. No fish were seen in any of those springs.

The algal community in streams and springs commonly consists of a few primary structural components of well anchored filamentous species which provide microhabitat for a multitude of additional plant and animal species. Some of the additional species are attached to the primary structural forms, while others grow within the structural matrix in a more independent fashion as tycnoplankton. In side areas, where flow rates are low, algae grow and accumulate to form suspended masses and floating mats where they perform a function similar to that just described. With minor variations, all of the study habitats follow this pattern. Flowing water is virtually non-existent in Shoshone North Pond, but a thick algal mat acts as a primary structural component there as well.

Phytoplankton are, by definition, the algae which live freely suspended in the water column. Most of them lack a mechanism to move enough to overcome the natural movements of the water. True phytoplankton communities usually develop in lakes, ponds, and large slow moving rivers. In most streams and rivers, flow rates are too high to allow time for phytoplankton communities to develop. In streams, "plankton" algae are usually organisms that have washed out of lakes and ponds or algae that have come from attached algal communities in the stream.

These generalizations are quite appropriate for all of our study habitats. In Preston Big Spring and Lockes Ranch Spring it is highly improbable that a true phytoplankton community could develop within 100 meters of the head pools due to the water velocity.

METHODS

AUFWUCHS

Collections of aufwuchs (periphyton) were made for the purpose of identifying the algal species present in each habitat. To that end, each habitat was examined thoroughly and grab samples were taken from many substrate types and current conditions. Samples included rock and stick scrapings, whole rocks, squeezings and cuttings of aquatic vascular plants, floating mats, and organic flocculum from benthic surfaces. A compound microscope and a dissecting microscope were taken to the field in July and August to aid in the collection of specialized structures needed to identify certain algal species.

Periphyton samples were preserved with Acid - Lugols solution. Preservative was added until a tea color was maintained in each sample. The quantity varied depending upon the amount of algae in the sample. Selected samples were kept alive by refrigeration and returned to Las Vegas for analysis.

Wet mounts were made for microscopic examination of all samples. In addition, Hyrax, a synthetic resin, was used to mount cleared diatoms. These cleared diatoms are necessary to observe the taxonomically useful shapes and decorative features of their cell walls. Periphyton species identifications were made using an inverted microscope with light-field phase contrast capabilities. Algal identifications were made to the species level or to the lowest taxonomic level possible.

PHYTOPLANKTON

Phytoplankton were counted using the inverted microscope method (Utermohl, 1931; 1958). This procedure facilitates the identification and enumeration of all phytoplankton size components and allows counts of not only the dominant species, but also the uncommon species.

One liter phytoplankton samples were collected from 10 centimeters below the surface with a 3 liter Van Dorn grab sampler. Phytoplankton samples were preserved in Acid - Lugols solution. One ml of preservative was added to each 100 ml of phytoplankton sample at the time of collection. Samples were stored in mason jars. The effective shelf life is 3 years or more when stored properly (Nauwerck, 1963) .

The nanoplanktonic species (less than 64 um) were counted at 400x magnification in one or more strips across the entire diameter of the plate chamber. The larger, more common forms were counted at 200x magnification in one or two across diameter strips. The entire plate chamber was then scanned at 100x magnification for the less common large algal species. All species not encountered at the higher magnifications were enumerated at 100x. When necessary, one or two strips 10 mm in length were enumerated at 1000x magnification (oil immersion) for the small forms. Due to extremely low algal densities, a low level of error was not always achieved.

RESULTS AND DISCUSSION

AUFWUCHS

Preston Big Spring

Flow rate and attachment substrates were the primary factors controlling the distribution of algal species in Preston Big Spring. Algae that formed the primary structural components were Spirogrya varians, Cladophora glomerata, and Dichotomosiphon tuberosus (Table 4). Near the head pool where flows were slow, extensive suspended and floating mats of S. varians developed. It was also found throughout the habitat where the flow slowed, usually in small open areas of aquatic weed beds. C. glomerata was very abundant in the main stream and occasionally in the shallow areas around Scirpus stems. It was attached to Rorippa in fast flowing water and formed streamers up to 30 cm long. Dichotomosiphon tuberosus dominated much of the shallow water among the sedge stems and Rorippa roots near the head pool. It formed dense, felty growths and provided a large surface area for epiphyte development.

Seventy-four species of algae were identified in samples collected from Preston Big Spring (Tables 4 and 5). Between the 50 and 100 meter transects, the mid-channel area was covered with small stones (1-15 cm in diameter). In June, some of the stones were covered with short (1-2 cm) Cladophora growths and a mixed diatom assemblage, while others were covered with Homeothrix juliana (blue-green). In July, August, and September, the Cladophora and diatoms had been largely replaced by H. juliana. In June, Chara vulgaris was found only in one small patch in a backwater area near the 60 meter transect. By July, Chara was beginning to grow between the stones in mid-channel. Once established there, it remained through August and September.

Diatoms were the most diverse group of algae encountered in the habitat. They comprised most of the chrysophytan species and more than 50 % of the total number of species identified throughout the study period (Table 5). Although green algae (Chlorophyta) were not as diverse as the diatoms, they accounted for most of the algal biomass present in the system. The blue-green algae (Cyanophyta) were nearly as diverse as the green algae in species numbers. Most of the Cyanophyta were found scattered and intermingled among the larger filamentous green algae in relatively low numbers. Oscillatoria nigra (blue-green) formed compact purple-black clumps (1-2 cm in diameter) at the water surface around the stems of Rorippa throughout the habitat. H. juliana formed nearly pure growths on mid-channel stones.

Table 4. Algae of the "Aufwuchs" Community in Preston Big Spring, 1980 (includes species found in the phytoplankton samples).

Species	Jun 7	Jul 12	Aug 9	Sep 6
CHLOROPHYTA				
Charales				
Chara vulgaris L.	*	*	**	**
Chaetophorales				
Protoderma viride Kuetzing (possibly)		*		
Stigeoclonium sp. Kuetzing			*	
Chlorococcales				
Elakatothrix viridis (Snow) Printz			*	
Pediastrum boryanum (Turp.) Menegh.			*	
Scenedesmus acutus Meyen			*	
S. bijuga (Turp.) Lagerheim		*	*	
Cladophorales				
Cladophora fracta (Dillw.) Kuetzing (probably)	*			*
C. glomerata (L.) Kuetzing	***	***	***	***
Rhizoclonium sp. Kuetzing (probably)			*	
Dichotomosiphonales				
Dichotomosiphon tuberosus (Braun) Ernst	***	***	***	***
Oedogoniales				
Oedogonium sp. Link			*	*
Zygnematales				
Cosmarium sp. Corda			*	
Mougeotia sp. Agardh	*			
Spirogyra spp. Link	*	*	**	*

(continued)

Table 4 . (continued)

Species	Jun 7	Jul 12	Aug 9	Sep 6
S. varians (Hass.) Kuetzing	***	***	***	***
Zygnema sp. Agardh	*	*	*	*
CHRYSOPHYTA Centrales				
Melosira varians Agardh	*			*
Stephanodiscus sp. Ehrenberg	*			
Chromulinales				
Chromulina sp. Cienkowski	*			
Pennales				
Achnanthes lanceolata (Breb.) Grun.			*	
v. dubia Grun.	**	*	*	*
A. minutissima Kuetzing	**	**	**	*
A. nollii Bock	*			
Amphora ovalis v. affinis (Kuetz.) V.H.	*	*	*	*
Anomoeoneis sphaerophora (Kuetz.) Pfitzer			*	
A. vitrea (Grun.) Ross		*		
Cocconeis placentula v. lineata (Ehr.) V.H.	**	**	**	**
Cymbella affinis Kuetzing	*	*	**	*
C. Cistula (Ehr.) Kirchn.	*		*	
C. microcephala v. crassa Reim.	*			
C. pusilla Grun. (probably)	*	*	*	

(continued)

Table 4 . (continued)

Species	Jun 7	Jul 12	Aug 9	Sep 6
Denticula tenuis Kuetzing	**	**	**	*
Diatoma vulgare Bory	*	*	*	**
Diploneis pseudovalis Hustedt			*	
Eunotia sp. Ehrenberg			*	
Fragilaria sp. Lyngbye	*	*	**	**
F. capucina v. mesolepta Rabh.			*	*
F. crotonensis Kitton	*	*		
Gomphonema sp. Agardh		*	*	
G. abbreviatum Agardh	**	**		
G. parvulum Kuetzing	**	**	**	**
G. subclavatum (Grun.) Patr.	*	*		*
G. truncatum Ehrenberg	*		*	*
Navicula spp. Bory	*		*	*
N. minima Grun.	*	*	*	*
Nitzschia sp. Hassall	*		*	*
N. denticula Grun.			*	
N. frustulum v. perpusilla (Rabh.) Grun.	*	*		*
N. linearis W. Smith			*	*
N. palea (Kuetz.) W. Smith			*	
Pinnularia sp. Ehrenberg				*
Rhopalodia gibba (Ehr.) Muller			*	*
Synedra amphicephala Kuetzing	*	*		*
S. rumpens Kuetzing			*	*

(continued)

Table 4 . (continued)

Species	Jun 7	Jul 12	Aug 9	Sep 6
S. ulna (Nitz.) Erhenberg	*	*	*	**
Terpsinoe sp. Erhenberg		*	*	*
Vaucheriales				
Vaucheria sp. De Candolle	*			
CYANOPHYTA Chroococcales				
Aphanothece sp. Naeglei			*	
Chroococcus turgidus (Kuetz.) Naeg.			*	*
Gloeocapsa sp. Kuetzing		*		
Gomphosphaeria aponina v. cordiformis Wolle			*	
Nostocales				
Homeothrix juliana (Menegh.) Kirchner	**	***	***	***
Raphidiopsis curvata Fritsch & Rich		*		
Oscillatoriales				
Lyngbya sp. Agardh	*			
Oscillatoria sp. Vaucher		*	*	*
O. chalybea Mertens	*	*	*	*
O. lacustris (Kleb.) Geitler		*	*	*
O. nigra Vaucher	*	*	*	*
O. tenuis Agardh	*	*	*	*
CRYPTOPHYTA Cryptophyceae				
Chroomonas acuta Utermohl		*		

(continued)

Table 1. (continued)

Species	Jun 7	Jul 12	Aug 9	Sep 6
Katablepharis ovalis Skuja	*	*		
EUGLENOPHYTA Euglenales				
Euglena sp. Ehrenberg			*	
Trachelomonas sp. Ehrenberg		*		

* Present in samples.
** Very commonly observed in samples.
*** Primary-structural-component of the "aufwuchs" community (e.g., _Cladophora_).

Table 5. Number of Algal Species, by Division, in Preston Big Spring, 1980

Division	Number of Species				
	June	July	August	September	Total
CHLOROPHYTA	8	9	13	8	17
CHRYSOPHYTA	27	20	26	24	41
CYANOPHYTA	5	8	9	7	12
CRYPTOPHYTA	1	2	-	-	2
EUGLENOPHYTA	-	1	1	-	2
Total number of taxa =	41	40	51	39	74

Lockes Ranch Spring

Lockes Ranch Spring is unique among the study habitats because it is a warm spring (37° C). Although it is not technically a thermal spring (temperature greater than 45° C) , it is warm enough to retard the growth of many algal species and give the prokaryotic blue-green algae (Cyanophyta) an advantage. This spring also has very low concentrations of nitrate-nitrogen (Table 3), a major nutrient for algal growth. At least six species of blue-green algae which may be able to fix atmospheric nitrogen were identified in the spring; several of them were primary structural components. If, through their nitrogen fixing activities, they are supplying most of the nitrogen to the spring system, their presence is uniquely fundamental to the entire trophic structure of the habitat. *Tolypothrix tenuis* is of particular interest in this regard because, under laboratory conditions, it fixed nitrogen at a rate of 0.24 grams/meter squared/12 hours (Round 1965). This is equivalent to 1315 kilograms of nitrogen/acre/year. Obviously, this species may be the single most important alga in Lockes Ranch Spring.

In Lockes Ranch Spring the primary structural components are three filamentous blue-green algae, i.e., *Tolypothrix tenuis*, *Plectonema wollei*, and *Rivularia* sp. (Table 6). In the shallow quiet water near meter 98, extensive suspended growths of *Oedogonium* (Chlorophyta) also develop. *T. tenuis* forms, by far, the bulk of the algal biomass in the habitat. It, and dense growths of *P. wollei*, develop cottony masses attached to the stems of *Scirpus*, boards, and other objects on the bottom. The clumps of algae are tough and form streamers up to 30 cm in length along the edges and into the faster flowing water of the stream. Most of the remaining algal species (Table 6) grow within this material as epiphytes or endophytes (i.e., under the sheaths of *Plectonema*).

What has tentatively been identified as *Rivularia* grows as a tough mat about 1-2 cm thick on solid substrates in mid-channel. The mat is layered in the typical fashion of *R. haematites* with extensive carbonate deposition. Small ostracods were found living inside the mat. As they feed on older algal material, passages are developed that form a network within the mat. We think the mat acts as a nursery for young ostracods where they are protected from predation by the fish which cannot penetrate the surface.

Sixty species from five algal divisions were identified in samples from Lockes Ranch Spring (Tables 6 and 7). The blue-green algae (Cyanophyta) were more important here in terms of biomass and the relative number of species present (Table 7) than they were in any of the other study habitats. The diatoms (Chrysophyta) were the most diverse algal group encountered, which is typical of most stream systems. *Ulothrix* sp., one of the few greens (Chlorophyta) in the habitat, commonly grew in abundance with *Plectonema wollei*. Cryptophytes and Euglenoids were minor components in Lockes Ranch Spring.

Table 6. Algae of the "Aufwuchs" Community in Lockes Ranch Spring, 1980 (includes species found in the phytoplankton samples).

Species	Jun 8	Jul 13	Aug 10	Sep 7
CHLOROPHYTA				
Chaetophorales				
Entocladia pithophorae (West) Smith (probably)	*	*	*	*
Charales				
Chara sp. Valliant			*	*
Cladophorales				
Rhizoclonium hieroglyphicum v. *macromeres* Wittr.				*
Oedogoniales				
Oedogonium sp. Link	**	***	***	**
Zygnematales				
Closterium sp. Nitzsch				*
Ulothrix sp. Kuetzing	**	**	**	**
CHRYSOPHYTA				
Chromulinales				
Chromulina sp. Cienkowski	*			
Pennales				
Achnanthes exigua Grun.	*	*	*	*
v. *heterovalva* Krasske	*	*		
A. minutissima Kuetzing			**	*
Anomoeoneis sp. Pfitzer			*	
Caloneis bacillaris v. *thermalis* (Grun.) A.U.	*			*
Cocconeis placentula v. *euglypta* (Ehr.) Cl. (probably)		*		
v. *lineata* (Ehr.) V. H.			*	*

(continued)

Table 6. (continued)

Species	Jun 8	Jul 13	Aug 10	Sep 7
Cymbella sp. Agardh			*	*
C. cistula (Ehr.) Kirchn.	*		*	*
C. pusilla Grun.			*	*
Denticula elegans Kuetzing	*	*	*	*
Diatoma sp. DeCandolle			*	*
Epithemia sp. Breb.	*	*		
E. adanata (Kuetz.) Breb.			*	*
Eunotia sudetica O. Mueller	**	*	*	*
Fragilaria sp. Lyngbye			*	*
Gomphonema spp. Agardh	*	*		*
G. affine Kuetzing	**	**	*	*
G. angustatum (Kuetz.) Rabh. (possibly)	*			
G. parvulum Kuetzing	*	*	*	*
Mastogloia smithii thwaites			**	*
Navicula sp. Bory	*	*		*
N. angusta Grun. (possibly)	*		**	*
N. cocconeiformis Greg. ex Grev.	*	*		*
N. pupla v. rectangularis (Greg.) Grun.			*	
N. radiosa Kuetzing			*	*
Nitzschia denticula Grun.	*	*	*	*
Pinnularia sp. Ehrenberg			*	
Rhopalodia gibba (Ehr.) Mueller			*	*
Synedra sp. Ehrenberg			*	
S. ulna (Nitz.) Ehrenberg	*	*		*

(continued)

Table 6 . (continued)

Species	Jun 8	Jul 13	Aug 10	Sep 7
CYANOPHYTA Chamaesiphonales				
Xenococcus sp. Thuret	*	*	*	*
Chroococcales				
Aphanothece stagnina (Spreng.) Braum			*	*
Chroococcus pallidus Naegeli	*	*	*	*
C. turgidus (Kuetz.) Naegeli		*	**	*
C. varius A. Braun	*	*		*
Gomphosphaeria aponina v. cordiformis Wolle		*	**	*
Nostocales				
Anabaena sp. Bory	*	*	*	*
Calothrix sp. Agardh	**	**	**	**
Nostoc sp. Vaucher (possibly)		*		
Plectonema wollei Farlow	***	***	***	***
Rivularia sp. Roth (possibly)	***	***	***	***
Tolypothrix tenuis (Kuetz.) emend. Smidt	***	***	***	***
T. willei Gardner	**	**	**	**
Oscillatoriales				
Lyngbya sp. Agardh	*	*		*
L. epiphytica Hieronymus	*	*	*	*
L. limnetica Lemmermann (possibly)	*			

(continued)

Table 5 . (continued)

Species	Jun 8	Jul 13	Aug 10	Sep 7
Oscillatoria sp. Vaucher	*	*	*	**
Phormidium sp. Kuetzing	*		*	*
Spirulina subsalsa Oersted	*	*		
CRYPTOPHYTA Cryptophyceae				
Katablepharis ovalis Skuja	*			
EUGLENOPHYTA Colaciales				
Colacium sp. Ehrenberg	*			
Euglena sp. Ehrenberg				*

* Present in samples.
** Very commonly observed in samples.
*** Primary-structural-component of the "aufwuchs" community (e.g., *Tolypothrix tenuis*).

Table 7 . Number of Algal Species, by Division, in Lockes Ranch Spring, 1980

Division	Number of Species				
	June	July	August	September	Total
CHLOROPHYTA	2	3	4	6	6
CHRYSOPHYTA	17	13	22	23	32
CYANOPHYTA	15	16	14	16	19
CRYPTOPHYTA	1	-	-	-	1
EUGLENOPHYTA	1	-	-	1	2
Total number of taxa =	36	32	40	46	60

Shoshone North Pond

Shoshone North Pond was unique because of the size and dynamics of the artifical habitat. The surface of the pond was covered with a crustose mat of rotting algae during the June sampling. However, during July and August, approximately one square meter of the habitat was open water. In September, the floating portion of the algal mat was absent upon arrival, but had reestablished itself by the time the field party left. This phenomenon was due to reduced incident radiation (cloud cover) and physical disruption (rain) in the days preceding the sampling period. During the sampling period, incident radiation increased, resulting in increased primary productivity of the algae. The result was floatation of submerged algae by oxygen bubbles, as well as rapid growth, which led to the reestablishment of a floating algal mat in the pond. In total, the pond had more algal species diversity than any of the other study habitats.

In this habitat, the primary structural component was Spirogyra crassa. It was extremely abundant and formed the floating surface mat. Spirogyra floats to the surface and accumulates, as excess oxygen produced during photosynthesis gets trapped in the filaments. Once at the surface, direct sunlight kills the cells, where they begin to rot. Beneath this layer, the Spirogyra filaments are healthy and abundant. They hang from the underside of the floating mat in long streamers that reach the bottom of the pond. In effect, the Spirogyra formed a floating, three-dimensional curtain occupying much of the water body. Within this structure, many other organisms lived. Due to the nature of the Spirogyra structure, the pond did not have a "typical" phytoplankton community. Since all of the algae were growing on or intermingled with other algae, it can be descibed as tychoplanktonic.

Among the filamentous green algae (including Mougeotia, Zygnema, and Oedogonium, as well as Spirogyra) other algal groups found suitable niches. The diatoms (23 species) were mostly attached to the filamentous forms. Twenty-two motile species from five algal divisions, 19 species of Chlorococcales and 9 desmid species, lived within the filamentous structure. Except for Gomphosphaeria aponina v. Cordiformis, and Oscillatoria sp., which were common, the blue-green algae (Cyanophyta) were of minor importance in the pond. A total of 99 species of algae were identified in the habitat. A complete species list is presented in Table 8 and a summary of taxa by division in Table 9 .

Within Shoshone North Pond, several of the major genera in the motile " Volvocine Line " were found. The " Volvocine Line " refers to a systematically increasing complexity in the colonial structure of a class of green algae, the Volvocales. Chlamydomonas, the most primitive evolutionary line, is single-celled. Pandorina usually has 16 cells, and Eudorina has up to 64 cells. These genera were present in the north pond. The last and largest member of the " Volvocine Line " is Volvox with up to 50,000 cells in each colony. Volvox was not found in the north pond, but was a major component of the plankton three meters away in the middle

Table 8. Algae of the "Aufwuchs" Community in Shoshone North Pond, 1980 (includes species found in the phytoplankton samples).

Species	Jun 10	Jul 15	Aug 11	Sep 8
CHLOROPHYTA				
Cladophorales				
Rhizoclonium hieroglyphicum (Ag.) Kuetzing			*	
Chlorococcales				
Ankistrodesmus falcatus (Corda) Ralfs		*	*	*
A. spiralis (Turner) Lemmermann		*		
Coelastrum cambricum v. intermedium (Bohl.) G.S. West	*	*	**	*
C. microporum Naegeli		**	*	
C. sphaericum Naegeli	*	*	*	*
Kirchneriella sp. Schmidle (possibly)			*	
Oocystis sp. Naegeli	*	*		
Pediastrum angulosum (Ehr.) Meneghini		*		
P. boryanum (Turp.) Meneghini	*	*	*	*
P. duplex Meyen		*	*	*
Scenedesmus abundans (Kirch.) Chodat			*	
S. arcuatus Lemmermann		*		
S. bijuga (Turp.) Lagerheim	*	*	*	*
v. alternans (Reinsch) Hansgirg		*	*	*
S. denticulatus Lagerheim			*	*
Tetraedron minimum (A. Braun) Hansgirg	*	*		*
v. scrobiculatum Lagerheim	*	*	*	
T. pentaedricum West α West	*			

(continued)

Table 8. (continued)

Species	Jun 10	Jul 15	Aug 11	Sep 8
T. trigonum v. papilliferum (Schroed.) Lemmer. ex. Brun.			*	
Oedogoniales				
Oedogonium spp. Link	*	*	*	*
Tetrasporales				
Gloeocystis sp. Naegeli		*		
G. ampla (Kuetz.) Lagerheim			*	*
Ulotrichales				
Cylindrocapsa sp. Reinsch (possibly)	*	*	*	*
Volvocales				
Chlamydomonas sp. Ehrenberg	*	*	*	
Eudorina elegans Ehrenberg		*		
Pandorina morum (Muell.) Bory	*	**	*	*
Sphaerellopsis fluviatilis (Stein) Pascher	*			
Zygnaematales				
Closterium sp. Nitzsch	*			
Cosmarium spp. Corda		*	*	*
C. intermedium Delp (possibly)	*	*	*	*
C. laeve Rabenh	*	*	*	*
C. rectangular v. hexagonium (Elfv.) West & West (probably)	*	*	*	*
Desmidium sp. Agardh (possibly)		*		
Mougeotia sp. Agardh		*	*	*
Spirogyra spp. Link		*	*	*

(continued)

Table 8. (continued)

Species	Jun 10	Jul 15	Aug 11	Sep 8
S. crassa Kuetzing	***	***	***	***
Staurastrum spp. Meyen	*	*	*	*
S. alternans Breb.	*	*	*	
S. manfeldtii Delp. v. (unknown)	*	*	*	*
Ulothrix sp. Kuetzing			*	
Zygnema sp. Agardh	*	*		
CHRYSOPHYTA Centrales				
Melosira granulata (Ehr.) Ralfs			*	
M. varians Agardh		*		
Chromulinales				
Chromulina sp. Cienkowski	*			
Mischococcales				
Peroniella sp. Gobi (possibly)				*
Chrysamoeba sp. Kelbs	*	*	*	*
Kephyrion sp. Pascher	*			
Ochromonadales				
Mallomonas sp. Perty	*	*	*	
Ochromonas sp. Wystozki	*			
Pennales				
Achnanthes sp. Bory			*	*
A. lanceolata (Breb.) Grun		*		
v. *dubia* Grun.	*	*		
A. minutissima Kuetzing		*	**	*

(continued)

Table 8. (continued)

Species	Jun 10	Jul 15	Aug 11	Sep 8
Amphora perpusilla (Grun.) Grun.	*		*	*
Cymbella sp. Agardh		*	*	*
C. minuta (Hilseex) Rabh.	*		**	*
Denticula elegans Kuetz.	*	*	*	
Epithemia sorex Kuetz.	*		*	*
E. turgida v. *westermannii* (Ehr.) Grun.	*	*	*	
Fragilaria sp. Lyngbye				*
F. brevistriata v. *inflata* (Pant.) Hust.	*	*	**	**
F. crotonensis Kitton	*	*	*	
Gomphonema truncatum Ehr.	*	*	*	
Navicula spp. Bory	*		*	*
N. accomoda Hust. (probably)	**		**	
N. radiosa Kuetz.	**	*	*	*
Nitzschia amphibia Grun.	*		*	*
Rhopalodia gibba (Ehr.) O. Muell.	*	*	*	*
Synedra sp. Ehrenberg	*		*	*
S. ulna (Nitz.) Ehr.	*	*	*	*
CYANOPHYTA Chroococcales				
Aphanocapsa sp. Naegeli	*	*	*	*
Aphanothece stagnina (Spreng.) Braun			*	*
Chroococcus minutus (Kuetz.) Naegli			*	*

(continued)

Table 8. (continued)

Species	Jun 10	Jul 15	Aug 11	Sep 8
Gomphosphaeria aponina v. cordiformis Wolle		**		
Merismopedia glauca (Ehr.) Naegeli	*		*	*
Nostocales				
Anabaena sp. Bory	*		*	
Oscillatoriales				
Lyngbya sp. Agardh		*	*	*
L. aestuarii (Mert.) Liebmann (probably)			*	*
L. limnetica Lemmermann (possibly)	*			
L. martensiana meneghini			*	*
L. nordgaardii Wille			*	*
Oscillatoria sp. Vaucher	*	*	*	*
O. sancta (Kuetz.) Gomont (probably)			*	
O. amoena (kuetz.) Gomont		*	*	*
Phormidium sp. Kuetzing			*	*
CRYPTOPHYTA Cryptophyceae				
Cryptomonas erosa Ehrenberg		*	*	*
Cyathomonas truncata From.	*			*
Katablepharis oblonga	*		*	
Protochrysis sp. Pascher	*			
Rhodomonas minuta v. nannoplanctica Skuja			*	

(continued)

Table 3 . (continued)

Species	Jun 10	Jul 15	Aug 11	Sep 3
	EUGLENOPHYTA Euglenales			
Euglena spp. Ehrenberg	**	**	**	*
Menoidium pellucidum Perty	*	**	*	*
Phacus sp. Dujardin				*
	PYRRHOPHYTA Dinokontae			
Gymnodinium sp. Stein	*	*	*	*
Peridinium sp. Ehrenberg			*	
P. inconspicuum Lemmermann			*	*
	Miscellaneous			
Bodo sp. Ehrenberg	*			
Phyllomitus apiculatus	*			

* Present in samples.
** Very commonly observed in samples.
*** Primary-structural-component of the "aufwuchs" community (e.g., *Spirogyra crassa*).

Table 9. Number of Algal Species, by Division, in Shoshone North Pond, 1980

Division	Number of Species				
	June	July	August	September	Total
CHLOROPHYTA	22	33	30	22	42
CHRYSOPHYTA	21	15	21	17	29
CYANOPHYTA	5	5	13	11	15
CRYPTOPHYTA	3	1	3	2	5
EUGLENOPHYTA	2	2	2	3	3
PYRRHOPHYTA	2	2	3	2	3
MISCELLANEOUS	2	0	-	-	2
Total number of taxa =	57	58	72	57	99

pond. Its absence from the north pond was probably due to grazing by fish. The Volvox colonies are large and should be spotted easily by the fish. The absence of fish in the middle pond may explain its abundance there. The algal community in the pond was very complex and typical of a highly nutrient-enriched shallow lake or pond.

Outflow of Ash Spring

The outflow of Ash Spring has the highest flow rate of the habitats studied. The spring head is distant from the study habitat, relative to the spring heads at Preston Big Spring and Lockes Ranch Spring. The water passes through agricultural areas and is used for irrigation before it reaches the study area. These activities add considerably to the nutrient load of the water and affect the quantity and quality of the algal community.

A complete list of the algal species identified from the outflow of Ash Spring is given in Table 10 . A wide variety of species (68) were found representing six algal divisions (Table 11).

Chara zeylanica (Chlorophyta), Compsopogon coeruleus (Rhodophyta), and Spirogyra sp. (Chlorophyta) formed the primary structural components within the algal community of this habitat. The Chara was "rooted" in some of the muddy bottom areas. The Compsopogon was usually attached to twigs and branches in the water, but it also formed extensive growths on the macrophyte Najas marina, which provided a secure anchor in the muddy bottom areas. Spirogyra developed massive growths over all areas with enough undergrowth of Chara, Najas, Potamogeton, or Compsopogon to keep it from being carried away in the current. The backwater and shallow side areas were always dominated by suspended and floating mats of Spirogyra . Reproductive structures adequate for proper species identification of several important algae, especially Spirogyra , were not found.

Although Chara was first observed in July near the 75 meter transect in a shallow area with extensive silt deposition, it was probably present in June as well, but was completely hidden by Spirogyra growing above it. After an extended search of the area, no reproductive material could be found, probably because of the apparent cropping of the new growth regions of the Chara by animals.

Most of the algal species diversity in the outflow of Ash Spring was due to diatoms (37 species). They were mostly epiphytic growths on the substrates at hand. Compsopogon and Chara were particularly excellent substrates. The flagellated organisms (Euglenophytes, Pandorina, Mallomonas, and the Cryptophytes) grew within the Spirogyra population in the quieter waters. The remaining species were epiphytic or tychoplanktonic and growing within the structure of the major forms.

Table 10. Algae of the "Aufwuchs" Community in the outflow of Ash Spring, 1980 (includes species found in the phytoplankton samples).

Species	Jun 15	Jul 15	Aug 12	Sep 9
CHLOROPHYTA				
Charales				
Chara zeylanica Kl. ex Willdenow		***	***	***
Cladophorales				
Rhizoclonium hieroglyphicum (Ag.) Kuetzing		*	*	*
Chaetophorales				
Aphanochaete repens Braun		*	*	*
Chlorococcales				
Characium sp. Braun		*		
C. ambiguum Herman		*	*	
Coelastrum sphaericum Nageli		*	*	
Tetraedron minimum v. *scrobiculatum*		*	*	*
Oedogoniales				
Oedogonium sp. Link		*	*	*
Volvocales				
Pandorina morum Bory		*		
Zygnematales				
Closterium sp. Nitzsch	*			
Cosmarium sp. Corda				*
Mougeotia sp. Agardh		*	*	*
Spirogyra sp. Link	***	***	***	***
Zygnema sp. Agardh				**

(continued)

Table 10. (continued)

Species	Jun 15	Jul 15	Aug 12	Sep 9
EUGLENOPHYTA Euglenales				
Euglena sp. Ehrenberg		*	*	*
Menoidium pellucidum Perty		*		
Notosolenus sp. Stokes	*			
Phacus sp. Dujardin		*		
CHRYSOPHYTA Centrales				
Biddulphia laevis Ehrenberg			*	
Cyclotella meneghiniana Kuetzing	*	*		*
Ochromonadales				
Mallomonas sp. Perty	*			
Pennales				
Achnanthes exigua Grun. (variety unknown)	*	*	*	*
A. lanceolata (Breb.) Grun.	*	*		*
A. minutissima Kuetzing	*	*	*	*
Amphora veneta Kuetzing	*	*	*	*
Anomoeoneis sp. Pfitzer	*			
Cocconeis placentula v. lineata (Ehr.) V.H.	**	**	**	**
Cymbella microcephala v. crassa Reimer			*	*
C. tumida (Breb. ex Kuetz.) V.H.			*	*
C. tumidula Grun. ex A.S.	*			
Denticula sp. Kuetzing	*	*	*	*

(continued)

Table 10. (continued)

Species	Jun 15	Jul 15	Aug 12	Sep 9
Eunotia pectinalis (O. Muell.) Rabh.	*	*	*	*
Fragilaria sp. Lyngbye			*	*
Gomphonema sp. Agardh	*	*	*	*
G. affine kuetzing			*	
G. angustatum (Kuetz.) Rabh.	*	*	*	*
G. parvulum Kuetzing	**	**	**	**
G. truncatum Ehrenberg				*
Gyrosigma sp. Hassall	*			*
G. acuminatum (Kuetz.) Rabh.	*			
Navicula sp. Bory	*	*	*	*
N. cincta (Ehr.) Ralfs	*	*	*	*
Nitzschia sp. Hassall	*	*		*
N. amphibia Grun.	*	*	*	*
Opephora sp. Petit (possibly)	*			
Pinnularia sp. Ehrenberg	*	*		*
Rhoicosphenia curvata (Kuetz.) Grun. ex Rabh.	**	**	*	*
Rhopalodia gibba (Ehr.) O. Mueller	**	**	*	*
Surirella angustata Kuetzing	*	*		*
S. ovalis Breb.	*			*
Synedra sp. Ehrenberg	*	*	*	*
S. actinastroides Lemmermann (probably)	**	**	**	**
S. acus Kuetzing	*	*	*	*
S. ulna (Nitz.) Ehrenberg	*	*	**	*
Terpsinoe americana (Bailey) Ralfs	*	*	*	*

(continued)

Table 10. (continued)

Species	Jun 15	Jul 15	Aug 12	Sep 9
CYANOPHYTA Nostocales				
Anabaena sp. Bory	*			*
Calothrix sp. Agardh				*
Raphidiopsis sp. Fritsch & Rich		*		
Oscillatoriales				
Lyngbya sp. Agardh	*		*	*
L. nordgaardii Wille		*		
Oscillatoria sp. Vaucher		*	*	*
O. lacustris (Kleb.) Geitler		*	*	*
Plectonema wollei Farlow (probably)			*	
CRYPTOPHYTA Cryptophyceae				
Chroomonas acuta		*		
Cryptomonas sp. Ehrenberg	*			
C. érosa Ehrenberg		*		
Katablepharis oblonga	*			
RHODOPHYTA Bangiales				
Compsopogon coeruleus (Balbis) Montagne	***	***	***	***
Miscellaneous				
Bodo sp. Ehrenberg	*			

* Present in samples.
** Very commonly observed in samples.
*** Primary structural component of the "aufwuchs" community (e.g., Chara zeylanica).

Table 11. Number of Algal Species, by Division, in the Outflow of Ash Spring, 1980

Division	Number of Species				
	June	July	August	September	Total
CHLOROPHYTA	2	12	9	9	14
CHRYSOPHYTA	31	25	24	30	37
CYANOPHYTA	2	4	3	5	7
CRYPTOPHYTA	2	2	-	-	4
EUGLENOPHYTA	1	3	1	1	4
RHODOPHYTA	1	1	1	1	1
MISCELLANEOUS	1	1	-	-	1
Total number of taxa =	40	48	38	46	68

PHYTOPLANKTON

Preston Big Spring

Algal data for plankton samples collected from Preston Big Spring in June and July are presented in Table 12. Phytoplankton samples were not collected in August and September. Twenty-nine taxa from five algal divisions were enumerated (Table 13). Total cell concentrations were very low in all samples from June and July , ranging from 10.6 to 251.1 cells per ml (Table 12). The variability in cell concentrations between replicates, especially in July, (Table 12) reflects the random input of periphyton into the moving water and the difficulty in accurately estimating such low cell concentrations.

In June, non-descript coccoid-green cells and monads (small flagellates) were the numerical dominants in the samples (Table 12). In July, particularly at the 20 m transect, Oscillatoria (a filamentous blue-green) was more important in terms of cell numbers. This is somewhat misleading because only 3 filaments per ml were counted and each filament had about 75 cells. When the mean number of algal units encountered are compared (Table 14), there is little difference between June and July samples.

All species found in the phytoplankton samples of this spring are members of the "aufwuchs" community. Their occurrence in the plankton is due to washout from the periphyton community. The "plankton" contribution to the algal biomass of the entire habitat is extremely small. The effect of massive periphyton washouts due to major disruptions (animals and man) would be quickly removed, as the material is carried out of the study habitat by the flow.

Lockes Ranch Spring

Algal data from plankton samples collected from Lockes Ranch Spring in June and July are presented in Table 15. Phytoplankton samples were not collected in August and September. Twenty taxa from five algal divisions were enumerated (Table 16). In June, the total cell concentrations were very low and, as in Preston Big Spring, highly variable between replicates. In July, the total cell concentrations were similarly variable but about 10 times higher than in June . The difference was due to the occurrence of Oscillatoria and Anabaena filaments in the July samples. These taxa had numerous cells in each filament. An examination of the mean number of algal particles or units per ml (Table 14) shows much less difference between the June and July samples. It follows that larger cell numbers do not necessarily increase the number of food particles in the water.

Diatoms and filamentous blue-green algae accounted for about one-half of the taxa encountered in June and July. This is reasonable given the

Table 12. Phytoplankton Concentrations at Preston Big Spring in cells/ml.

Species	Transect / Replicate	June 7, 1980 20m 1	June 7, 1980 20m 2	June 7, 1980 100m 1	June 7, 1980 100m 2	July 12, 1980 20m 1	July 12, 1980 20m 2	July 12, 1980 100m 1	July 12, 1980 100m 2
	CHLOROPHYTA Chlorococcales								
Elakatothrix viridis (Snow) Printz								2	
	Cladophorales								
Cladophora sp. Kuetzing				0.1					
	Zygnematales								
Spirogyra sp. Link		0.3	1.1		3.1	0.1	0.7		
	CHRYSOPHYTA Centrales								
Stephanodiscus sp. Ehrenberg			4						
	Chromulinales								
Chromulina sp. Cienkowski		6							
	Pennales								
Achnanthes minutissima Kuetzing						1			3

(continued)

Table 12. (continued)

Species	Transect	June 7, 1980				July 12, 1980			
		20m		100m		20m		100m	
	Replicate	1	2	1	2	1	2	1	2
Anomoeoneis vitrea (Grun) Ross								1	
Cocconeis placentula v. lineata (Ehr.) V.H.		0.03	0.2	0.04	0.2	1	1	0.04	0.2
Denticula tenuis Kuetzing			0.02			5	1	4	6
Diatoma vulgare Bory					0.5				0.1
Fragilaria crotonenis Kitton						0.2	0.3	0.04	0.2
Gomphonema sp. Agardh						2			
G. parvulum Kuetzing									1
Navicula spp. Bory		0.04	0.02		0.04				
Nitzschia sp. Hassall		0.2	0.2		0.02				
Synedra amphicephala Kuetzing							1		
S. ulna (Nitz.) Erhenberg		0.1	0.1	.5	0.9		0.1	0.1	0.2
Pennates							1		1
CYANOPHYTA Chroococcales									
Gloeocapsa sp. Kuetzing								4	
Nostocales									
Raphidiopsis curvata Fritscht Rich									4
Oscillatoriales									
Lyngbya sp. Agardh					0.04				
Oscillatoria sp. Vaucher						224	58		
O. lacustris (Kleb.) Geitler						2.8		15.5	10.7

(continued)

Table 12. (continued)

Species	Transect / Replicate	June 7, 1980 20m 1	June 7, 1980 20m 2	June 7, 1980 100m 1	June 7, 1980 100m 2	July 12, 1980 20m 1	July 12, 1980 20m 2	July 12, 1980 100m 1	July 12, 1980 100m 2
CRYPTOPHYTA									
Cryptophyceae									
<u>Chroomonas acuta</u> Utermohl								7	
<u>Katablepharis ovalis</u> Skuja			2.0			1	1		
EUGLENOPHYTA									
Euglenales									
<u>Trachelomonas</u> sp. Ehrenberg									0.1
Miscellaneous									
Coccoid green cell			4	10					
Monad		4	12		20	14	11	23	9
Total number of cells/ml =		10.9	23.6	10.6	24.8	251.1	75.1	56.7	35.5

Table 13. Number of "Phytoplankton" Species by Taxonomic Group Found in Preston Big Spring, 1980.

Taxon	Number of Species June	July	Total
CHLOROPHYTA	2	2	3
CHRYSOPHYTA	9	12	16
CYANOPHYTA	1	4	5
CRYPTOPHYTA	1	2	2
EUGLENOPHYTA	0	1	1
MISCELLANEOUS	2	1	2
Total number of taxa =	15	22	29

TABLE 14. Mean phytoplankton cells per milliliter and algal units per milliliter by habitat and date (values rounded to nearest whole number).

Habitat	June		July	
	Cells/ml	Algal units/ml	Cells/ml	Algal units/ml
Preston Big Sp.	18	17	105	37
Lockes Ranch Sp.	26	16	361	33
N. Shoshone Pond	3386	418	2101	190
Ash Sp.	27	27	79	32

Table 15. Phytoplankton Concentration at Lockes Ranch Spring in cells/ml.

Species	Transect / Replicate	June 8, 1980 15 meter 1	June 8, 1980 15 meter 2	June 8, 1980 100 meter 1	June 8, 1980 100 meter 2	July 13, 1980 15 meter 1	July 13, 1980 15 meter 2	July 13, 1980 100 meter 1	July 13, 1980 100 meter 2
	CHLOROPHYTA								
Oedogonium sp. Link				5.3	5.4				
	Zygnematales								
Ulothrix sp. Kuetzing							3.3	2.7	3
	CHRYSOPHYTA								
Chromulina sp. Cienkowski				4					
	Pennales								
Gomphonema sp. Agardh								3	2
G. angustatum (Kuetz.) Rahh. (possibly)				0.1					
G. parvulum Kuetzing									3
Navicula spp. Bory			4	0.2	4				
Synedra ulna (Nitz.) Ehrenberg				0.02					
pennate diatoms						3	2.1	5	3
	CYANOPHYTA Nostocales								
Anabaena sp. Bory				0.8	4	16	113	68	59
	Oscillatoriales								
Lyngbya sp. Agardh			.02		4			5.2	
L. limnetica Lemmermann (possibly)		0.7	1.8	0.1					
Oscillatoria spp. Vaucher					0.04	58.7	163	690.2	220.2
Spirulina subsalsa Oersted		4	6		2	0.1	3		1

(continued)

Table 15. (continued)

Species	Transect / Replicate	June 8, 1980 15 meter 1	June 8, 1980 15 meter 2	June 8, 1980 100 meter 1	June 8, 1980 100 meter 2	July 13, 1980 15 meter 1	July 13, 1980 15 meter 2	July 13, 1980 100 meter 1	July 13, 1980 100 meter 2
CRYPTOPHYTA Cryptophyceae									
Katablepharis ovalis Skuja				2					
EUGLENOPHYTA Colaciales									
Colacium sp. Ehrenberg			.02						
Miscellaneous									
Coccoid green cells <5 μm dia.		4	6		2				
monad 5-10 μm dia.				0.02	10	1	3	7	4
golden browncell				0.2					
filament				40					
Total number of cells/ml =		8.7	17.8	52.7	31.4	78.8	287.4	781.1	295.2

Table 16. Number of "Phytoplankton" Species by Taxonomic Group Found in Lockes Ranch Spring, 1980.

Taxon	Number of Species		
	June	July	Total
CHLOROPHYTA	1	1	2
CHRYSOPHYTA	4	3	7
CYANOPHYTA	5	4	5
CRYPTOPHYTA	1	0	1
EUGLENOPHYTA	1	0	1
MISCELLANEOUS	4	1	4
Total number of taxa =	16	9	20

importance of these two groups in the "aufwuchs" community of Lockes Ranch Spring (Tables 6-7). The remaining taxa appear to be random occurrences of the various species living in the aufwuchs community.

Shoshone North Pond

As discussed in the "aufwuchs" section, Shoshone North Pond had a very different type of dynamic system when compared to the other habitats studied. Many algal species (98) were found living among the Spirogyra filaments. Except in September, there was essentially no open water and therefore, no strictly planktonic community. It could best be called tychoplanktonic, as would be found in the littoral region of a shallow eutrophic lake or pond. The plankton samples were collected by gently parting the surface mat and sampling the resulting open water. The September samples were collected before the mat reformed. Phytoplankton data for Shoshone North Pond are given in Tables 17 and 18. Eighty taxa from 5 algal divisions were enumerated during the four month study (Table 19).

Considerable variation occurred in cell counts between replicate samples on all sampling dates (Tables 17 and 18). This is most likely due to the unique algal structure of the pond and the disturbance to the mat during sampling. Another artifact of the sampling technique is that Spirogyra crassa , the alga responsibile for most of the biomass in the pond, was practically excluded from the samples, especially in July and August, when some open water was available. The September sample was closest to being a true plankton sample because the Spirogyra was on the bottom. Thus, sampling for phytoplankton in this habitat is inappropriate as long as the mat formation is a dominant structure.

The mean algal concentration of the four replicate samples taken in June was 3386 cells per ml. The high cell count was largely due to Aphanocapsa, a colonial blue-green alga. The colonies were not abundant and they occurred in only one replicate in July, but the number of cells was high (4146 cells per ml), thereby having a great influence on the mean value. If the total number of algal units are compared to the cell count (413 and 3386, respectively, Table 14) a dramatic difference can be seen. In July and August a similar situation was found. In situations like this, where large numbers of cells are concentrated in one unit, chance encounters of the food item by herbivores is lessened. The shape and size of colonial and filamentous algae often make them difficult for herbivores to eat. Relatively few large colonial and filamentous algae were in the September samples. They may have been carried to the bottom with the Spirogyra.

The algal communities were similiar throughout the study. Flagellated species from most major groups were common. Euglena, Menoidium, and Pandorina were especially prominent in most of the samples. Ten species from the order Chlorococcales were present in high numbers during the study. Both the flagellates and the Chlorococcales are

Table 17. Phytoplankton Concentration at Shoshone North Pond in June and July cells/ml.

Species	Replicates	June 9, 1980				July 14, 1980			
		1	2	3	4	1	2	3	4
CHLOROPHYTA Chlorococcales									
Coelastrum microporum Naegeli						252	16	240	736
C. sphaericum Naegeli		32	160	64	16	100		32	128
Oocystis sp. Naegeli		44	20	36		6			16
Pediastrum boryanum		32	32			1.1		16	
P. duplex Meyen						0.5		0.6	1
Scenedesmus arcuatus Lemmermann							16		16
S. bijuga (Turp.) Lagerheim		8	20			24	8	24	20
Tetraedron minimum (A. Braun) Hansgirg		60	20		12		6		
v. scrobiculatum				20		22		10	34
T. pentaedricum West West				8					
Oedogoniales									
Oedogonium spp. Link						0.04		0.4	20
Ulotrichales									
Cylindrocapsa sp. Reinsch (possibly)						12.4	0.2	9.1	246
Tetrasporales									
Gloeocystis sp. Naegeli									36
Volvocales									
Chlamydomonas sp. Ehrenberg			10	24					
Eudorina elegans Ehrenberg						1.1		5.4	
Pandorina morum (Muell.) Bory		48	160	48	32	66.9	1	3	480
Sphaerellopsis fluviatilis (Stein) Pascher				4	20				

(continued)

Table 17. (continued)

Species	Replicate	June 9, 1980				July 14, 1980			
		1	2	3	4	1	2	3	4
Zygnaematales									
Closterium sp. Nitzsch			2						
Cosmarium spp. Corda			4			10			22
Desmidium sp. Agardh (possibly)						15			
Mougeotia sp. Agardh						2.2	0.4	2.0	8
Spirogyra spp. Link			16			0.5		0.4	2.4
S. crassa Kuetzing		73	10	47	68				
Staurastrum spp. Meyen		2	2			2.9	0.04	2.6	18
Zygnema sp. Agardh			32						
CHRYSOPHYTA									
Centrales									
Melosira varians Agardh						0.04			
Chromulinales									
Chromulina sp. Cienkowski		52	70	36	20				
Chrysamoeba sp. Kelbs		16				2			4
Kephyrion sp. Pascher					12				
Ochromonadales									
Mallomonas sp. Perty		36	20	25	16	0.1			
Ochromonas sp. Wystozki				20	20				

(continued)

Table 17. (continued)

Species	Replicate	June 9, 1980 1	2	3	4	July 14, 1980 1	2	3	4
Pennales									
Achnanthes lanceolata									6
A. minutissima Kuetzing								2	
Cymbella sp.		8			28	4		2	6
F. crotonensis Kitton			20			0.9	0.1	1.2	6
Navicula spp. Bory		36		32					
N. accomoda Hust. (probably)			10						
Rhopalodia gibba (Ehr.) O. Muell.			12	2		0.1			2
S. ulna (Nitz.) Ehr.			1		2		0.1		
pennate diatoms				2.8		2.3	0.5		2
CYANOPHYTA Chroococcales									
Aphanocapsa sp. Naegeli		4016	1000	3904	1864				4146
Mer'smopedia glauca (Ehr.) Naegeli					256				
Nostocales									
Anabaena sp. Bory			60						
Oscillatoriales									
Lyngbya sp.						6.8			254
L. limnetica Lemmermann (possibly)		40	22	36	34				
Oscillatoria sp. Vaucher						131.5	15.4	198.4	380
O. amoena (Kuetz.) Gomont						24.2			

(continued)

Table 17. (continued)

Species	Replicates	June 9, 1980				July 14, 1980			
		1	2	3	4	1	2	3	4
CRYPTOPHYTA Cryptophycene									
Cryptomonas erosa Ehrenberg							2	2	8
Cyathomonas truncata From.		28			4				
Katablepharis oblonga		12	20		4				
EUGLENOPHYTA Euglenales									
Euglena spp. Ehrenberg		28	30	32	40	1.04	0.02	1.64	8.02
Menoidium pellucidum Perty		2	3	4	5	18	2.2	14.8	20
PYRRHOPHYTA Dinokontae									
Gymnodinium sp. Stein				24				4	2
MISCELLANEOUS									
Bodo sp. Ehrenberg		4							
Monads <5 μm dia.		4	110			74	30	122	108
Monads 5-10 μm dia.		96	10	84	48		12	6	14
Phyllomitus apiculatus				12					
Total number of cells/ml =		4677	1876	4490	2501	781.6	109.4	745.7	6767.4

Table 18. Phytoplankton Concentration at Shoshone North Pond in August and September (cells/ml).

Species	Replicates	August 11, 1980				September 8, 1980			
		1	2	3	4	1	2	3	4
CHLOROPHYTA									
Clorococcales									
Ankistrodesmus falcatus (Corda) Ralfs			1	2.5	4				2
Coelastrum cambricum									
v. intermedium (Bohl.) G.S. West		48	5.9	60	80	16	32	5.1	16
C. microporum Naegeli				80					
C. sphaericum Naegeli			16	160	32	28			
Kirchneriella sp. Schmidle (possibly)		52	4	10					
Pediastrum boryanum (Turp.) Meneghini		0.3	0.8					64	
P. duplex Meyen		0.3	0.3		1.3		0.6		
Scenedesmus abundans (Kirch.) Chodat				20					
S. bijuga (Turp.) Lagerheim		0.1	0.3			24			
v. alternans (Reinsch) Hansgirg		0.2	2.1		32			0.3	
S. denticulatus Lagerheim					8		8	16	
Tetraedron minimum (A. Braun) Hansgirg						8	12	4	4
v. scrobiculatum Lagerheim		12	24	10	28				
T. trigonum									
v. papilliferum (Schroed.) Lemmer. ex. Brun.				10	4				
Oedogoniales									
Oedogonium spp. Link					3.1				
Ulotrichales									
Cylindrocapsa sp. Reinsch (possibly)		108	15	20.9	1.2				
Volvocales									
Chlamydomonas sp. Ehrenberg							4		

(continued)

Table 18. Phytoplankton Concentration at Shoshone North Pond in August and September (cells/ml).

Species	Replicates	August 11, 1980				September 8, 1980			
		1	2	3	4	1	2	3	4
CHLOROPHYTA Clorococcales									
Ankistrodesmus falcatus (Corda) Ralfs			1	2.5	4				2
Coelastrum cambricum									
v. *intermedium* (Bohl.) G.S. West		48	5.9	60	80	16	32	5.1	16
C. microporum Naegeli				80					
C. sphaericum Naegeli			16	160	32	28			
Kirchneriella sp. Schmidle (possibly)		52	4	10					
Pediastrum Boryanum (Turp.) Meneghini		0.3	0.8					64	
P. duplex Meyen		0.3	0.3		1.3		0.6		
Scenedesmus abundans (Kirch.) Chodat				20					
S. bijuga (Turp.) Lagerheim		0.1	0.3			24			
v. *alternans* (Reinsch) Hansgirg		0.2	2.1		32			0.3	
S. *denticulatus* Lagerheim					8		8	16	
Tetraedron minimum (A. Braun) Hansgirg						8	12	4	4
v. *scrobiculatum* Lagerheim		12	24	10	28				
T. trigonum									
v. *papilliferum* (Schroed.) Lemmer. ex. Brun.				10	4				
Oedogoniales									
Oedogonium spp. Link					3.1				
Ulotrichales									
Cylindrocapsa sp. Reinsch (possibly)		108	15	20.9	1.2				
Volvocales									
Chlamydomonas sp. Ehrenberg							4		

(continued)

Table 18. (continued)

Species	Replicates	August 11, 1980				September 8, 1980			
		1	2	3	4	1	2	3	4
<u>Pandorina</u> <u>morum</u> (Muell.) Bory		0.5	12	20	14		8	0.6	
Zygnaematales									
<u>Cosmarium</u> spp. Corda		2		1.8	1.1	1			
<u>C. rectangular</u> v. <u>hexagonium</u> (Elfv.) West & West (probably)		2		0.1	1	4			
<u>Mougeotia</u> sp. Agardh			0.4			4			
<u>Spirogyra</u> spp. Link		0.2	0.1	0.1			2	0.6	
<u>S. crassa</u> Kuetzing		0.2		0.7					
<u>Staurastrum</u> spp. Meyen		2		0.2	1				
<u>S. alternans</u> Breb.		2	-						
<u>S. manfeldtii</u> Delp. v. (unknown)		2		0.8	0.1	1		-	1
<u>Ulothrix</u> sp. Kuetzing					2.4				
CHRYSOPHYTA Centrales									
<u>Melosira</u> <u>granulata</u> (Ehr.) Ralfs		1.7		0.8					
Ochromonadales									
<u>Mallomonas</u> sp. Perty		2							
Pennales									
<u>Achnanthes</u> sp. Bory					4	8	12		
<u>Amphora</u> <u>perpusilla</u> (Grun.) Grun.			2						
<u>Denticula</u> <u>elegans</u> Kuetz.		-							

(continued)

Table 13. (continued)

Species	Replicates	August 11, 1980				September 8, 1980			
		1	2	3	4	1	2	3	4
Fragilaria sp. Lyngbye								40	
F. crotonensis Kitton			0.1				4		
Gomphonema sp. Agardh					1				
Navicula radiosa Kuetz.		0.1	2	0.9	1				
Rhopalodia gibba (Ehr.) O. Muell.				0.1					0.3
Synedra sp. Ehrenberg		6	10	13	4			4	
S. ulna (Nitz.) Ehr.							1.5		0.3
Pennate diatoms		4	2.1		4.1	5			4.5
CYANOPHYTA Chroococcales									
Aphanocapsa sp. Naegeli		28	630	480	140	120		32	
Chroococcus minutus (Kuetz.) Naegli									48
Gomphosphaeria aponina v. _cordiformis_ Wolle			0.4						
Oscillatoriales									
Lyngbya sp. Agardh			2						
Oscillatoria sp. Vaucher		26.9	51	140	45.6	9.5	100	27.5	192
CRYPTOPHYTA Cryptophyceae									
Cryptomonas sp. Ehrenberg		10	4			12	3	8	8
C. erosa Ehrenberg				0.1					
Cyathomonas truncata From.						12	4		
Katablepharis oblonga				10					

(continued)

Table 18 (continued)

Species	Replicates	August 11, 1980				September 8, 1980			
		1	2	3	4	1	2	3	4
Rhodomonas minuta v. *nannoplanctica* Skuja					4				
EUGLENOPHYTA Euglenales									
Euglena spp. Ehrenberg		26	10	6.9	7	5	10.5	8	12
Menoidium pellucidum Perty		38	38	26.1	49	52	48.5	63	61
Phacus sp. Dujardin							1		
PYRRHOPHYTA Dinokontae									
Gymnodinium sp. Stein		2	2	20	8	12	8	12	36
Peridinium sp. Ehrenberg						3	5		
P. inconspicuum Lemmermann		14	18	20	12	4	1	4	1
Miscellaneous									
Green cells		312	580	610	316	162	784	20	8
Filament							24		1.5
Monads (<5μm)		6	20	300	132	380	400	71	388
Monads (between 5 and 10μm)		4		10	16	96	104	28	49
Total number of cells/ml -		713	1454	2035	957	967	1577	408	833

Table 19. Number of "Phytoplankton" Species by Taxonomic Group Found in Shoshone North Pond, 1980.

Taxon	Number of Species June	July	August	September	Total
CHLOROPHYTA	16	18	25	16	36
CHRYSOPHYTA	12	12	11	7	20
CYANOPHYTA	4	4	4	3	9
CRYPTOPHYTA	2	1	4	2	4
EUGLENOPHYTA	2	2	2	3	3
PYRROPHYTA	1	1	2	3	3
MISCELLANEOUS	4	3	3	4	5
Total number of taxa =	41	39	51	38	80

commonly found in the plankton and littoral region of large lakes and ponds. They usually attain high concentrations only under eutrophic conditions, i.e., high nutrient concentrations. Several desmids and filamentous members of the Zygnematales were well established in the pond. A high diversity of diatom species was present, but they were generally in low concentrations. This was possibly due to their epiphytic nature and the general exclusion of filamentous taxa from the sample. In addition to Aphanocapsa, other blue-green algae were important in the samples; Lyngbya in June, Oscillatoria in July, August, and September.

The algal mat which dominated the pond during the summer should break down in the fall (the process had already begun in August) and as the water opens up, a phytoplankton community may develop. A much higher percentage of the Spirogyra crassa cells from the September aufwuchs sample had formed zygospores. This reflects the cooler fall weather, shorter days, and the decline of the vegetative filaments.

Outflow Of Ash Spring

Algal data for plankton samples collected from the outflow of Ash Spring in June and July are given in Table 20. Phytoplankton samples were not collected in August and September. Forty taxa from six algal divisions were enumerated (Table 21). Even though algal diversity was fairly high in these samples, cell concentrations were very low (27 and 79 cells per ml for June and July , respectively (Table 14)). The pair of higher cell concentrations for Oscillatoria in July (rep. No. 2=137, rep. No. 4=43.3) were again due to the filamentous nature of the organism (Table 20). A comparison of mean algal units per ml between June and July (27 and 32, respectively) confirm this relationship (Table 14).

Much of the diversity in the samples was due to pennate diatoms (30 to 50 percent). In July this was less so, with Chlorophyta, Euglenophyta, Cyanophyta, and Cryptophyta contributing three or four species each (Table 21).

As with Preston Big Spring and Lockes Ranch Spring the "phytoplankton" were derived from the "aufwuchs" community and accounted for a minor portion of the algal biomass in the habitat. They similarly had a minor role in the ecology of the habitat.

Table 20. Phytoplankton Concentration at the outflow of Ash Spring in cells/ml.

Species	Replicate	June 10, 1980 1	June 10, 1980 2	June 10, 1980 3	June 10, 1980 4	July 15, 1980 1	July 15, 1980 2	July 15, 1980 3	July 15, 1980 4
	CHLOROPHYTA Chlorococcales								
Coelastrum sphaerieum Naegeli									6
Tetraedron minimum v. scrobiculatum									1
	Volvocales								
Pandorina morum Bory									1.1
	Zygnematales								
Closterium sp. Nitzsch		0.02							
Mougeotia sp. Agardh							0.2		0.2
Spirogyra sp. Link					0.14	1.2			
	EUGLENOPHYTA Euglenales								
Euglena sp. Ehrenberg perty								0.2	0.1
Menoidium pellucidum perty									0.3
Notosolenus sp. Stokes			2						
Phacus sp. Dujardin							0.2		
	CHRYSOPHYTA Ochromonadales								
Mallomonas sp. Perty			2						

(continued)

Table 20. (continued)

Species	Replicate	June 10, 1980 1	2	3	4	July 15, 1980 1	2	3	4
Pennales									
Anomoeoneis sp. Pfitzer		0.02							
Cocconeis placentula v. lineata (Ehr.) V. H.		0.34	0.58	0.44	0.30	0.2	0.5	0.6	1.8
Denticula sp. Kuetzing			0.02						
Gomphonema sp. Agardh			0.02	0.2	0.08	3	2		3
G. angustatum (Kuetz.) Rabh.		0.10	0.2						
G. parvulum Kuetzing						1			
Gyrosigma sp. Hassall		0.08	0.10			0.2	0.2	.01	0.2
G. acuminatum (Kuetz.) Rabh.				0.02	0.08				
Navicula spp. Bory		0.48	0.52	1.42	0.80				
Nitzschia spp. Hassall		0.04	0.06	0.14					
Rhoicosphenia curvata (Kuetz.)Grun. ex Rabh.		0.16	0.08	0.04					
Rhopalodia gibba (Ehr.) O.Mueller		0.04		0.02					
Synedra sp. Ehrenberg			0.12	0.04					
S. ulna (Nitz.) Ehrenberg		0.10	0.12	0.14	0.12	0.1	0.2	0.1	0.1
Pennate diatoms							5	5	5
CYANOPHYTA Nostocales									
Anabaena sp. Bory		1.0							
Raphidiopsis curvata Fritsch and Rich									3

(continued)

Table 20. (continued)

Species	Replicate	June 10, 1980 1	2	3	4	July 15, 1980 1	2	3	4
Oscillatoriales									
Lyngbya sp. Agardh		0.02	0.14	0.30	0.20				
Oscillatoria sp. Vaucher						5.2	137	4.1	43.3
O. lacustris (k ɛb.) Geitler							4.2	0.8	0.4
CRYPTOPHYTA Crytophyceae									
Chroomonas acuta						1			
Cryptomonas sp. Ehrenberg		2				1	1		1
C. erosa Ehrenberg								1	
Katablepharis oblonga		4	6	0.02			2		
RHODOPHYTA Bangiales									
Compsopogon coeruleus (Balbis) Montagne									2.5
Miscellaneous									
Green filament				0.3					
Coccoid cell		2		0.12	0.04				
Monad 4-6		10	8	24	26	11	23	26	10
Bodo sp. Ehrenberg		2							
Total number of cells/ml=		22.4	19.96	26.9	37.76	23.9	175.32	40.09	70.6

Table 20 (continued)

Species	Replicate	June 10, 1980 1	2	3	4	July 15, 1980 1	2	3	4
Pennales									
Anomoeoneis sp. Pfitzer		0.02							
Cocconeis placentula									
v. *lineata* (Ehr.) V. H.		0.34	0.58	0.44	0.30	0.2	0.5	0.6	1.8
Denticula sp. Kuetzing			0.02						
Gomphonema sp. Agardh			0.02	0.2	0.08	3	2		3
G. *angustatum* (Kuetz.) Rabh.		0.10	0.2						
G. *parvulum* Kuetzing						1			
Gyrosigma sp. Hassall		0.08	0.10			0.2	0.2	.01	0.2
G. *acuminatum* (Kuetz.) Rabh.				0.02	0.08				
Navicula spp. Bory		0.48	0.52	1.42	0.80				
Nitzschia spp. Hassall		0.04	0.06	0.14					
Rhoicosphenia curvata (Kuetz.)Grun. ex Rabh.		0.16	0.08	0.04					
Rhopalodia gibba (Ehr.) O.Mueller		0.04		0.02					
Synedra sp. Ehrenberg			0.12	0.04					
S. *ulna* (Nitz.) Ehrenberg		0.10	0.12	0.14	0.12	0.1	0.2	0.1	0.1
Pennate diatoms							5	5	5
CYANOPHYTA Nostocales									
Anabaena sp. Bory		1.0							
Raphidiopsis curvata Fritsch and Rich									3

(continued)

Table 21. Number of "Phytoplankton" Species by Taxonomic Group Found in the outflow of Ash Spring, 1980.

Taxon	Number of Species		
	June	July	Total
CHLOROPHYTA	2	4	5
EUGLENOPHYTA	1	3	4
CHRYSOPHYTA	14	7	17
CYANOPHYTA	2	3	5
CRYPTOPHYTA	2	4	4
RHODOPHYTA	0	1	1
MISCELLANEOUS	4	1	4
Total number of taxa =	25	23	40

INVERTEBRATE COMMUNITIES

INTRODUCTION

Information regarding the invertebrate fauna inhabiting the springs of Nevada is not abundant. Most conspicuous among the literature are works by Brues (1928 and 1932), Kennedy (1917), and La Rivers (1949 and 1951). Works by these authors are generally pre-1950's with little emerging in the literature since that time. A review of the taxonomic and ecological literature reported for aquatic insects by Merritt and Cummins (1978) supports this statement.

No comprehensive information on invertebrate collections could be found regarding the four springs we studied. La Rivers worked on invertebrates from Ash Spring, but was primarily interested in the Naucoridae and particularly interested in areas near thermal headsprings (La Rivers, 1949; 1951). Brues collected invertebrates extensively throughout Nevada, but also restricted his studies to thermal springs (Brues, 1928; 1932). Brues did report invertebrate collections in the general vicinity of the study springs, but the only reasonably comparable collections were from Duckwater (Brues, 1932) which may have some faunistic similarity to Lockes Ranch Spring. Preston Big Spring and Shoshone North Pond are generally 10 degrees C cooler than the springs Brues investigated. There was no previous information available regarding the invertebrate fauna of Shoshone North Pond. In fact, this habitat has only existed for aproximately 10 years. In short, there is no specific information on invertebrates available in the literature for any of the study springs.

MATERIALS AND METHODS

Although a variety of "quantitative" devices exist for sampling invertebrates in flowing waters, it has been demonstrated that considerable differences in estimates of standing crop exist in data generated using different quantitative devices (Kroeger, 1972; Pollard and Kinney, 1979). Use of a quantitative sampling device in a manner for which it was not designed can also generate questionable results (Chutter, 1972). Since the primary purpose of the invertebrate portion of this study was description of invertebrate fauna and comparison of their densities in various habitats, a strictly quantitative approach was considered to be less appropriate than rigorously applied standardized procedures. In addition, the springs we studied had mats of emergent vegetation or filamentous algae as the dominant invertebrate habitat. None of the conventional invertebrate sampling devices are useful for sampling this type of habitat. Amcros (1980) has recently described a device which may provide for standard samples of littoral vegetation. It may be useful to evaluate the potential of this device for future studies.

Three basic types of sampling devices were employed for collection of invertebrates: an 80 micron Wisconsin plankton net 30 cm long with a mouth opening of 11.5 cm; a triangular dip net 74 cm long with a mouth opening of 20 x 20 x 26 cm; and a standard 6" x 6" Eckman Dredge . These devices were used in the following standardized manners.

80 MICRON WISCONSIN NET

The plankton net was used in flowing water systems (Preston, Lockes, and Ash springs) as a drift net. The net was placed in the water approximately 10 cm below the surface and handheld in place for a period of time estimated to allow a length of at least 50 meters to flow past the net. At the end of the filtering time the net was removed from the water, rinsed, and samples transfered to collection bottles. The samples were then fixed in 5% formalin and the volumes adjusted to 50 ml.

At Shoshone North Pond the plankton net was used to filter a three liter water sample collected with a standard Van Dorn bottle from approximately 10 cm below the surface in open waters. After collection, the sample was concentrated in a plankton net which was then rinsed and samples fixed as described above. In addition, during the June sampling round, grabs of algal mat were collected and washed into the plankton net. These samples were collected with the triangular dip net and transferred to the plankton net. During the July, August, and September sampling periods, algae samples were quantified by carefully pulling the plankton net vertically through an algae mat and removing the excess algae from the perimeter of the net. This method appeared to trap a cylinder of water and algae in a reasonably quantitative manner.

TRIANGULAR DIP NET

The dip net was employed to sample rocky bottom areas in flowing water and vegetation mats in flowing and still water. The sampler was employed essentially like a Surber or box sampler in rocky bottom areas (Needham and Needham, 1962). Extensive effort was expended to sample an area 25 x 25 cm (1/16 of a square meter) from surface to bottom (important to note in vegetation mats). In vegetation mats occurring in standing water, this method allowed for removal by hand of a cube of vegetation, placing the plant material directly in the net. After the vegetation was removed from the sampling area, the net was swept through the open water to capture any suspended invertebrates. All samples were rinsed completely in a screen bottomed bucket (U.S. Standard 30 Mesh) and the easily removable vegetation rinsed, inspected, and discarded. Mollusks were removed from the samples by swirling the sample in a round-bottomed container and pouring off the lighter debris and organisms. The molluscan portion of the sample was either field-processed or counted in the laboratory by Jerry Landye with the aid of a dissecting microscope. The rest of the invertebrate sample was either field-sorted in a shallow white pan while the organisms were still alive or preserved in formalin, returned to the laboratory, dyed with rose bengal solution, and hand sorted. This procedure for sorting macroinvertebrates is the most thorough but also the most time consuming (Cummins, 1962). The quality control criteria for sorting was to sort until no organisms were found in 2 minutes of continuous examination. All samples sorted in the laboratory were examined by a taxonomist as a further quality control measure.

A modification of the standardized dipping method was used at Shoshone North Pond in August and September in an attempt to adequately sample the shallow (less than 10 cm) areas of littoral vegetation. The dip net was pushed vigorously through a stand of shallow littoral vegetation over approximately 24 cm of surface area four times. The samples were then processed as previously described.

ECKMAN DREDGE SAMPLES

Dredge samples were collected from muddy, flocculent, or soft-bottom habitats for which the sampler is best suited (Cummins, 1962). Samples were collected by hand and transfered directly to a screen-bottomed bucket (U.S.Standard 30 Mesh). The sample was vigorously rinsed until the mud and fine sediments were removed and then transferred to a one-quart mason jar. Samples were either field-sorted or processed in the laboratory as described above.

COUNTING PROCEDURES

All organisms removed from Eckman dredge and standardized dip samples were identified at appropriate magnification and counted. Data were recorded on bench sheets. Identifications were to the lowest possible taxon using standard taxonomic references. Plankton or algae mat samples were counted by removing sub-samples from the sample with a Stempple Pipette. The sub-sample was placed in a Sedgewick Rafter cell and counted until either 100 organisms had been encountered or 10% of the total sample volume had been counted. Because of extremely low densities in the plankton samples from flowing spring systems, these samples consistently required that 10% of the sample volume be counted.

DATA ANALYSIS PROCEDURES

Invertebrate data were compiled on bench sheets during identification and enumeration procedures. Software was developed for data organization and entry into computer storage. All life-stages identified for taxa were stored separately. Additional software was developed for output tabulation of raw data (Appendix C), calculation and output tabulation of basic statistics (Appendix D), and calculation of percentage data from raw data (used in preparation of pie diagrams). Diversity index calculations required that all life-stages of a taxa be summed prior to that calculation. Software was developed to accomplish this and report the necessary summations as "aggregates" (Appendix D). All diversity index calculations were performed using aggregated data where appropriate.

RESULTS

The percentage of mollusks, based on numbers per square meter, was over 95% of the total number of invertebrates in at least one habitat in all spring systems sampled. The actual percent composition by habitat of various taxonomic groups collected are graphically presented in the fish gut analysis section. There were indications of seasonal shifts in species composition and/or age structure of invertebrate populations sampled in all aquatic ecosystems. Variability of sampling methods and the limited number of samples collected from habitats preclude extensive statistical treatment for most data.

The four aquatic ecosystems examined exhibited marked differences in their invertebrate fauna. Preston Big Spring contained the most diverse fauna with greater than 40 taxa being collected. Shoshone North Pond also contained a diverse fauna, though less diverse than Preston Big Spring. The study area in the outflow of Ash Spring was fairly poor in species richness but had quite a few species of chironomids. Lockes Ranch Spring was quite poor in species richness with generally, only one representative for any major group (Table 22). The taxonomic organization presented in Table 22 follows Edmondson, 1959, although current nomenclature has been substituted in some cases (eg: Cnidaria for Coelenterata).

ZOOPLANKTON

In all the flowing springs, true planktonic organisms were quite sparse (less than 1 animal/liter). It was obvious from observations of these collections that the plankton of the flowing water systems we studied was virtually nonexistent. This is further supported by the fact that all organisms observed in plankton samples from flowing water systems were typically found in association with littoral vegetation (e.g., rhizopods and cyclopoid copepods). Shoshone Ponds, on the other hand, have a true planktonic community. In the north pond, which was intensively studied, the plankton community appeared to be associated with algal mats. A limited study of the planktonic communities of the three ponds was performed in June, July, and September to determine the potential effect of fish populations on plankton density. It was obvious that the center pond (no fish) had much higher open water plankton densities during June than either the north or south pond (Table 23). Late summer plankton densities were quite low (less than 10 animals/liter) in all ponds.

Undoubtedly, the lack of a true planktonic community in the north and south ponds, which are inhabited by fish, is a function of fish predation on the larger planktonic forms (copepod adults and cladocerans). Specific descriptions of invertebrate communities associated with algal mats and open water in Shoshone North Pond will follow.

Table 22. - Inventory Of Invertebrate Taxa Collected
p= Preston Big Spring , l= Lockes Ranch Spring
a= Outflow Of Ash Spring , s= Shoshone North Pond

Spring	Species*	Common Name
	ACTINOPODA	
---s	actinopoda (119)	protozoans
	RHIZOPODA	
---s	unidentifiable rhizopoda (125)	protozoans
p-as	difflugidae (124)	protozoans
p-as	*Arcella* sp. (121)	protozoans
---s	*Arcella dentata* (122)	protozoans
p-as	*Centropyxis aculeata* (120)	protozoans
---s	*Centropyxis hemisphaerica* (126)	protozoans
---s	*Trigonopyxis arcula* (123)	protozoans
	CILIOPHORA	
--a-	ciliophora (127)	protozoans
	CNIDARIA	
p---	*Chlorohydra viridissima* (033)	hydras
	TURBELLARIA	
p---	turbellaria (probably microturbellaria) (032)	flatworms
p---	*Dugesia* sp. (031)	flatworms
	NEMATODA	
pl-s	nematoda (161)	round worms
	GASTROTRICHA	
---s	gastrotricha (165)	gastrotrichs
	ROTIFERA	
---s	unidentifiable rotifera (136)	rotifers
p--s	*Lecane* sp.1 - 170 microns (132)	rotifers
---s	*Lecane* sp.2 - 100 microns (133)	rotifers
---s	*Lecane* sp.3 (130)	rotifers
---s	*Lepadella* sp.1 (131)	rotifers
p---	*Lepadella* sp.2 (138)	rotifers
p-as	*Monostyla* sp. (134)	rotifers
---s	*Scaridium longicaudum* (135)	rotifers
---s	*Testudinella* sp. (137)	rotifers

(cont.)

Table 22. - (cont.)

Spring	Species	Common Name
	OLIGOCHAETA	
plas	oligochaeta - all, includes fragments (141)	worms
p-a-	immature tubificid without hair chaete (146)	tubificids
p-a-	immature tubificid with hair chaete (151)	tubificids
pla-	*Limnodrilus hoffmeisteri* (147)	tubificids
p---	*Limnodrilus spiralis* (148)	tubificids
p-a-	*Tubifex tubifex* (150)	tubificids
p-as	naididae (142)	naids
p---	*Nais* sp. 1 ** (152)	naids
p---	*Nais* sp. 2 ** (153)	naids
p---	*Nais* sp. 3 ** (154)	naids
p---	*Nais* sp. 4 ** (155)	naids
p---	*Nais simplex* (159)	naids
p---	*Pristina* sp. 1 ** (156)	naids
p---	*Pristina* sp. 2 ** (157)	naids
pl--	*Pristina aequiseta* (158)	naids
p--s	*Pristina longiseta leydyi* (143)	naids
	HIRUDINEA	
p--s	unidentified hirudinea *** (139)	leeches
	CLADOCERA	
---s	juvenile cladocera (116)	water fleas
---s	*Alona rectangula* (115)	water fleas
---s	*Chydorus sphaericus* (117)	water fleas
	COPEPODA	
pl-s	cyclopoid copepodite (111)	copepods
pl-s	copepod nauplius (112)	copepods
p---	*Eucyclops agilis* (113)	copepods
p--s	*Macrocyclops albidus* (114)	copepods
	OSTRACODA	
pl--	unidentifiable ostracoda (004)	bean shrimp
pla-	cypridae ** (003)	bean shrimp
	AMPHIPODA	
pl--	*Hyalella azteca* (001)	scuds
	COLLEMBOLA	
-l--	*Sminthurides* sp. (189)	springtails

(cont.)

Table 22. - (cont.)

Spring	Species	Common Name
	EPHEMEROPTERA	
p-as	_Callibaetis_ sp. (027)	mayflies
	ODONATA	
p-a-	unidentifiable zygopteran (050)	damselflies
plas	immature coenagrionidae (049)	damselflies
plas	_Argia_ spp. (042)	damselflies
---s	_Coenagrion resolutum_ ** (047)	damselflies
---s	_Ischnura_ sp. - immature (005)	damselflies
p--s	immature anisopteran (030)	dragonflies
plas	immature libellulidae (045)	dragonflies
pl--	_Anax amazili_ ** (178)	dragonflies
--a-	_Erpetogomphus_ sp. (048)	dragonflies
---s	_Erythemis_ sp. ** (171)	dragonflies
p---	_Orthemis ferruginea_ (046)	dragonflies
--a-	_Progomphus_ sp. - (199)	dragonflies
pl-s	_Tarnetrum corruptum_ (041)	dragonflies
	HEMIPTERA	
---s	immature belastomatidae (173)	toe biters
pl--	_Belastoma flumineum_ (105)	toe biters
-l--	_Merragata hebroides_ - adult (190)	velvet waterbugs
p---	_Hesperocorixa_ sp - adult (191)	water boatmen
	COLEOPTERA	
p---	unidentifiable coleopteran larvae (034)	beetles
---s	_Agabus_ sp. - adult (174)	beetles
p---	_Anacaena_ sp. - larvae (039)	beetles
---s	_Bidessus affinis_ - adult (197)	beetles
---s	_Copelatus_ sp. - adult (188)	beetles
p---	_Deronectes_ sp. - adult (180)	beetles
---s	_Derovatellus_ sp. - adult (175)	beetles
p---	_Enochrus_ sp. - larvae (036)	beetles
---s	_Enochrus_ sp. - adult (181)	beetles
p---	_Hydrobius fuscipes_ - adult (176)	beetles
--a-	_Hygrotus_ sp. - adult (198)	beetles
---s	_Laccophilus atristernalis_ (196)	beetles
---s	_Laccophilus decipiens_ - adult (184)	beetles
---s	_Laccobius agilis_ - adult (186)	beetles
--a-	_Microcylloepus_ sp. - larvae (182)	beetles
--a-	_Microcylloepus moapus fraxinus_ (179)	beetles
---s	_Paracymus subcupreus_ - adult (187)	beetles

(cont.)

Table 22. - (cont.)

Spring	Species	Common Name
p---	*Peltodytes* sp. - larvae (035)	beetles
p--s	*Peltodytes callosus* - adult (185)	beetles
p---	*Rhantus* sp. adult ** (040)	beetles
p---	*Tropisternus* sp. - larvae (038)	beetles
p---	*Tropisternus elipticus* - adult (037)	beetles
---s	*Tropisternus sublaevis* - adult (183)	beetles
	TRICHOPTERA	
p---	hydroptilidae-unidentifiable larvae (011)	microcaddisflies
p---	hydroptilidae - unidentifiable pupae (009)	microcaddisflies
p-a-	hydroptilidae - adult (010)	microcaddisflies
p-a-	*Hydroptila* sp. - larvae (017)	microcaddisflies
p---	*Hydroptila* sp. - adult (019)	microcaddisflies
p---	*Leucotrichia* sp. - larvae (018)	microcaddisflies
p---	*Leucotrichia* sp. - pupae (021)	microcaddisflies
p---	*Leucotrichia* sp. - adult (020)	microcaddisflies
--a-	*Nectopsyche* sp. - larvae (022)	caddisflies
p-a-	*Oxyethira* sp. - larvae (012)	microcaddisflies
p---	*Oxyethira* sp. - pupae (013)	microcaddisflies
p---	*Oxyethira* sp. - adult (014)	microcaddisflies
p---	*Stactobiella* sp. - larvae (015)	microcaddisflies
p---	*Stactobiella* sp. - pupae (016)	microcaddisflies
	LEPIDOPTERA	
p---	lepidoptera - single specimen * (104)	butterflies
p---	*Parargyractis* sp. (103)	butterflies
	DIPTERA	
p---	unidentifiable dipteran larvae (098)	flies
p---	unidentifiable dipteran pupae (099)	flies
plas	unidentified chironomid - larvae ** (072)	midges
plas	unidentified chironomid pupae ** (070)	midges
p---	chironomidae - adult (071)	midges
p-as	unidentifiable chironomid larvae (078)	midges
p---	unidentifiable chironomid pupae (079)	midges
p---	*Ablabesmyia* sp. - pupae (094)	midges
p---	*Ablabesmyia* sp. - larvae (090)	midges
--a-	*Chironomus* sp. - larvae (074)	midges
--a-	*Chironomus* sp. - pupae (075)	midges
pla-	*Cricotopus* spp. - larvae (081)	midges

(cont.)

Table 22. - (cont.)

Spring	Species	Common Name
p-a-	*Cricotopus* spp. - pupae (088)	midges
--a-	*Cryptochironomus* sp. - larvae (073)	midges
--a-	*Cryptochironomus* - sp. - pupae (077)	midges
p---	*Corynoneura* sp. - larvae (192)	midges
--a-	*Dicrotendipes* sp. - larvae (076)	midges
p---	*Eukiefferiella* sp. - larvae (082)	midges
p---	*Heterotrissocladius* sp. - larvae (085)	midges
p---	*Micropsectra* sp. - larvae (084)	midges
p---	*Micropsectra* sp. - pupae (09?)	midges
p---	*Microtendipes* sp. - larvae (083)	midges
p---	*Microtendipes* sp. - pupae (089)	midges
p---	*Paratanytarsus* sp. - larvae (195)	midges
-l--	*Paratendipes* sp. - larvae (091)	midges
-l--	*Paratendipes* sp. - pupae (092)	midges
p---	*Pentaneura* sp. - pupae (087)	midges
p---	*Phaenopsectra* sp. - larvae (194)	midges
--a-	*Polypodilum* sp. - larvae (080)	midges
p---	*Pseudochironomus fulviventris* (193)	midges
p---	*Dixa* sp. - larvae (167)	dixidae
p---	*Psychoda* sp. - larvae (168)	psychodidae
p---	*Simulium* sp. - larvae (169)	black flies
-la-	ceratopogonidae - palpomia group (095)	no-seeums
---s	ceratopogonidae - pupae (172)	no-seeums
pl--	*Culicoides* sp. - larvae (096)	no-seeums
---s	*Odontomyia* sp. - larvae (166)	snipe flies
---s	*Stratiomys* sp. (110)	snipe flies
pl-s	*Limonia* sp. - larvae (097)	crane flies
	ORIBATEI	
p-as	*Hydrozetes* sp. (101)	semiaquatic mite
	HYDRACARINA	
pl-s	unidentifiable hydracarina (106)	water mite
---s	*Arrenurus* sp. (109)	water mite
p---	*Lebertia* sp. (102)	water mite
-l--	*Sperchon* sp. (107)	water mite
-l--	*Thermacarus nevadensis* (108)	water mite
	GASTROPODA	
p-a-	*Ferrissia fragilis* (068)	limpets
p---	*Fluminicola* n.sp. - juvenile **** (051)	snails
p---	*Fluminicola* n.sp. - sub-adult **** (052)	snails
p---	*Fluminicola* n.sp. - adult **** (053)	snails

(cont.)

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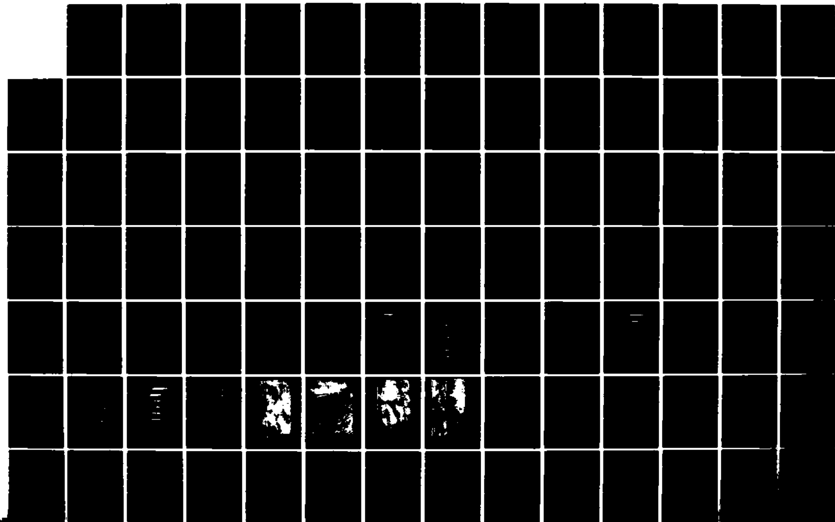

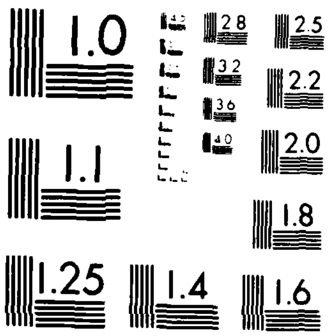

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Table 22. - (cont.)

Spring	Species	Common Name
---s	Gyraulus parvus - juvenile (062)	snails
---s	Gyraulus parvus - sub-adult (061)	snails
---s	Gyraulus parvus - adult (060)	snails
-l--	hydrobioid - new genus - juvenile **** (057)	snails
-l--	hydrobioid - new genus - sub-adult **** (058)	snails
-l--	hydrobioid - new genus - adult **** (059)	snails
--a-	Melanoides tuberculatus - all (064)	snails
---s	Physa virgata - juvenile (056)	snails
---s	Physa virgata - sub-adult (055)	snails
--as	Physa virgata - adult (054)	snails
	PELYCEPODA	
p---	Pisidium sp.1 - juvenile (066)	clams
p---	Pisidium sp.1 - adult (067)	clams
	MISCELLANEOUS	
pl-s	terrestrial insects (aphids,etc) (170)	terrestrials
p--s	fish eggs (162)	fish
p--s	larval fish (163)	fish
--a-	Cichlisoma nigrofasciatum - (164)	fish

* numbers at end of names represent computer number assignment only, not taxonomic heirarchy

** further specimens or taxonomic work is required to identify this species

*** collected in qualitative samples only

**** endemic species

TABLE 23. Comparison of the plankton densities in the Shoshone Ponds. $\bar{X}$ = mean numbers/liter for limited counts of comparable vertical plankton tows.

	June Sampling Round Mean number/liter	taxa	July Sampling Round Mean number/liter
North Pond	13.3	Rhizopods	0.0
Center Pond	320.9	Copepods, Cladocerans	182.9
South Pond	32.1	Rhizopods, Rotifers, Copepods	28.9

ECKMAN DREDGE SAMPLES

Eckman dredge samples were collected from all springs. Invertebrates were extremely sparse in dredge samples, except at Ash Spring, where molluscan density was very high. Specific descriptions of invertebrates collected in dredge samples from the springs will follow.

STANDARDIZED DIP SAMPLES

Dip samples were collected at Preston Big Spring, Lockes Ranch Spring, and Shoshone North Pond. Extremely high densities of invertebrates were observed in samples from Preston and Lockes springs. Dip samples were used exclusively at Preston Big Spring due to the large amount of emergent vegetation and algal growth at that spring. Returns from dip samples were very good at Preston and Lockes spring. Specific descriptions of invertebrates collected at each spring system will follow.

DESCRIPTIONS OF INVERTEBRATE COMMUNITY COMPOSITION

Preston Big Spring

Invertebrate communities collected in Preston Big Spring were considerably different in the various habitats sampled. The habitats sampled represented all the major aquatic vegetation types present in the spring, as well as a rocky bottom area in fast flowing water. The gravel-bottom area in swift water, near the 100 meter transect, was dominated by micro-caddisflies and the snail, *Fluminicola* n.sp., except during September, when *Hyalella azteca* became important in this habitat (Tables C and D 01-04). The *Rorippa* (nasturtium) mats at the edge of the fast flowing area were dominated by the amphipod, *Hyalella azteca*, *Oxyethira* sp., *Fluminicola* n.sp., chironomids, and turbellarians (Tables C and D 05-08). During the June sampling trip, very high numbers of orbatid semiaquatic mites occurred in nasturtium mats, but these animals were not prominent in samples from any other habitat or during the following sampling rounds. Nasturtium - algae habitats in slow flowing waters and sedge root mats were dominated by *Fluminicola* n.sp., the micro-caddisfly, *Oxyethira* sp., turbellarians, oligochaetes, and chironomids (Tables C and D 09-14). The age structure of *Fluminicola* n.sp populations was different in the various habitats, with juvenile snails appearing more important in habitats nearer the head pool than in habitats further downstream. The numbers of *Leucotrichia* sp. appeared to increase dramatically in the gravel and sand habitat. This was a result of the close attachment of *Leucotrichia* to gravel substrates. This taxon was not adequately sampled in June and July. To correct this during August and September, all rocks contained in a dip sample were closely examined and the Leucotrichia larvae and pupae were counted in the field.

In all habitats, except gravel and sand, immature damselflies became an important part of the community structure in August and September, while immature dragonflies became abundant in September. Muddy habitats, sampled in August, were dominated by Fluminicola n.sp., while shallow littoral vegetation sampled in September was dominated by ostracods, Fluminicola n.sp.(field observations), turbellarians, beetles, and immature damselflies. By September, a majority of the immature damselflies had become identifiable as Argia spp. Raw data listing the numbers of each species per square meter for all replicate samples collected are presented in Tables C 01 through 24. Basic statistics generated by species and for totals are presented in Tables D 01 through 24.

Lockes Ranch Spring

Although the number of species observed at Lockes Ranch Spring was quite low (Table 22), the abundance of animals per square meter was quite high in some habitats. Drift, mud, and sandy gravel habitats contained the lowest invertebrate densities, while Utricularia mats and algae-sedge mats contained quite high densities of invertebrates. Densities of the hydrobioid snail and Pristina aequiseta populations both reached 30,000 to 40,000 individuals per square meter. Both organisms are quite small in terms of total individual biomass. Amphipods, mollusks, and oligochaetes appeared to be the dominant taxa associated with Utricularia mats while chironomids, mollusks, and oligochaetes appeared to be important in algae-sedge mats. Although the densities were quite low, the flocculent mud and sandy gravel areas were dominated by chironomids (Paratendipes sp.). Raw data listings and basic statistics for all samples collected are presented in Tables C 25 through 48 and D 25 through 48, respectively.

The distribution and abundance of aquatic invertebrates at Lockes Ranch Spring remained very constant, with minor changes over the entire four month study. As a result of processing errors in the algae and sedge samples, the naiad worms appeared to fluctuate considerably on a monthly basis. In reality, their populations did not fluctuate dramatically. In the Utricularia substrate, there were indications of fluctuations in taxa in qualitative observations conducted in cooler portions of the habitat. This particular substrate should be carefully monitored for seasonal fluctuations.

Shoshone North Pond

Open water zooplankton was not as important as zooplankton associated with the algal mat in the pond. The algal mat community represented the major habitat for microcrustaceans in Shoshone North Pond and probably provided a useable refuge for zooplankton production in the pond. Open water zooplankton density was higher in June than July sampling, but that was probably a function of residual algal mat species being collected in water grabs rather than any real change in zooplankton density. This is supported by the fact that almost all the species observed in the open water plankton samples were found in algal mat samples. Since very few invertebrates were collected in dip or dredge samples in June and July, it would appear that algal mat areas provided the major portion of the food resource for the fish population in Shoshone North Pond during this period.

Microcrustacean (copepods and cladocerans) abundance in algal mats appeared to remain constant throughout the study period, while invertebrate populations in littoral vegetation increased in August and September. Rhizopod populations in the algal mat habitat declined dramatically after July, but the timing of this was unclear due to inadequate preservation of August algal mat samples. Beginning in July, immature damselflies and dragonflies became abundant in littoral vegetation. In addition, a variety of adult aquatic beetles became abundant in August and September. Raw data listing and basic statistics for all samples collected are presented in Tables C 49 through 64, and D 49 through 64 respectively.

Outflow Of Ash Spring

The aquatic habitat in the outflow of Ash Spring was primarily a mud bottom with algae or macrophyte cover and occasional pools with sandy bottoms. Very low densities of all invertebrates, except the introduced Oriental snail *Melanoides tuberculatus,* occurred in every habitat sampled. The sandy pool habitat was especially poor. Macrophyte-covered mud (primarily Spiny Naiad) was the most diverse habitat in the study area accounting for the majority of species observed. Invertebrate densities other than *M. tuberculatus* increased in the spiny naiad-mud habitat in August and September . Chironomids appeared to be relatively important in this system although the total dominance of *M. tuberculatus* made determination of important species difficult. Raw data listings and basic statistics are presented in Tables C 65 through 80, and D 65 through 80, respectively, for all samples collected.

CONCLUSIONS

Invertebrate populations at Preston Big Spring are very diverse and abundant. The trophic resource available for fish populations is very large and diversified in this spring. Populations of invertebrates at Lockes Ranch Spring, although not very diverse, are quite abundant in macrophyte beds. Macrophyte beds in general, appear to provide the optimal habitat in the natural springs. In Shoshone Ponds, an artificial habitat with extremely low water flow, the major food resource appears to be associated with algal mats in early summer and with littoral vegetation and algal mats in fall. Alteration of algal mat density in this pond could drastically alter the habitat available for invertebrate colonization and, in turn, the food resource available to the fish population. The outflow of Ash Spring is so completely dominated by _Melanoides tuberculatus_ that it appears few other invertebrates are well established in the study reach of this spring outflow. It is difficult to evaluate the food resource at this study site or the consequences of alterations on that system. Fish must rely heavily on chironomids and on the drift or food sources falling into the water since _M. tuberculatus_ is not a good food resource.

MOLLUSCA

Due to the endemic nature of the aquatic molluscan resources of Nevada, it is important to address this unique invertebrate fauna separately. Very little comprehensive information is published on the aquatic mollusks of Nevada (Landye, 1973). Scientific freshwater molluscan investigations of southern Nevada began about 1859 and subsequent work was sporadic until the 1960's. In the 1960's D. W. Taylor began collecting freshwater mollusks found in the area. In 1969, J. J. Landye began his inventory work in the area. W. L. Pratt began his collection of freshwater and terrestrial mollusks in Nevada in 1976. Therefore, it has been only in the last 20 years that the species diversity of mollusks have begun to be understood. The major portion of the endemic molluscan fauna is hydrobioid gastropods which are found in desert springs. It is for this reason that any reduction in spring discharges will cause a major stress on these endemic molluscan species. It is certain that additional human population pressure will increase the rate at which introductions of detrimental exotic molluscan species will be made to these unique aquatic systems.

Many of these unique hydrobioid snails are known, but remain undescribed in the scientific literature. As indicated by the frequency of recent discoveries of new endemic freshwater molluscan species, there are probably several other unknown hydrobioid species still to be discovered in isolated springs in Nevada. In the four areas that specifically were inventoried for this project, two endemic hydrobioid species were found. In addition, within the four valleys containing our specific study areas, a total of eight endemic hydrobioid species have been found during investigations conducted over the last 11 years. An additional four undescribed species have been recently discovered in Steptoe Valley .

Hydrobioid gastropods are found in many of the desert springs in western North America, including Mexico. Most of these species are restricted to one spring system within one basin. In the literature, these mollusks are referred to as hydrobiid (Hydrobiidae) gastropods, but recent taxonomic investigations by Davis (1979) have changed their higher systematic position to the hydrobioid gastropods. Due to their long separation in time and space, these hydrobioid species have become highly endemic in spring systems that have maintained themselves for millions of years. Fossil investigations in western Arizona have provided evidence of Miocene desert springs including a hydrobioid fauna. As demonstrated by Davis (1979), live hydrobioid-hydrobiid snails can be utilized as living fossils. From these living fossils, valuable information on rates of zoological evolution and plate tectonics can be ascertained. Thus, the hydrobioid gastropods of Nevada should be treated as living fossils, with great care taken to preserve their populations.

Some of Nevadas springs have been shown to have existed continuously since at least Pliocene times ([illegible]). In addition, the water from some desert springs has been dated, using the radiocarbon method, to be in excess of 1000 years old. These facts should be considered in terms of the total antiquity of desert springs of western North America, including Nevada. If groundwater pumping does not "dry" up the spring and cause extirpation of endemic molluscan species, then long term pumping may cause changes in the distant future. An example of groundwater pumping causing extirpation of species is the spring south of Palomas, Chihuahua, Mexico. Groundwater pumping in the Deming, New Mexico area has caused the cessation of spring flow, extirpating three endemic hydrobioid species, and one endemic fish, Cyprinodon n.sp.

Aquatic molluscan inventories of White River, Pahranagat, Spring, and Railroad valleys are essentially complete, while the molluscan resources of Steptoe, Snake, and Monitor valleys remain largely unknown.

White River Valley (Preston Big Spring)

Within Preston Big Spring, only one endemic gastropod was found, Fluminicola n.sp. This undescribed species is also found in other springs in White River Valley, i.e., Moorman and Hot Creek springs. Moorman and Hot Creek springs also support Tryonia clathrata which is endemic to the White River system, including the Pahranagat and Muddy River valleys. This species is declining in numbers and any additional stress to the species will seriously jeopardize its continued existence.

Most of the springs on the eastern slope of the valley support an endemic undescribed Fontelicella species. These snails are restricted to aquatic vegetation in headsprings such as Hardy, Emmigrant, Flag, and Butterfield springs. In the latter three springs, there also is an undescribed Fluminicola. Systematic investigation has yet to be completed to ascertain whether these populations of Fluminicola are of the same species as the populations at Moorman, Preston Big, and Hot Creek springs. Note that the term Fluminicola is used here, eventually the Nevada Fluminicola will be put into a new genus.

Railroad Valley (Lockes Ranch Spring)

An undescribed genus-species of gastropod is found in the Lockes Ranch Spring. This snail is also found in other springs on the Lockes Ranch, i.e., Reynolds, and Corral springs.

Found on the eastern slope of Railroad Valley is an undescribed Fontelicella from at least three springs near Current. Habitat preference for this species is flowing water in headspring areas and usually on hard substrates such as Rorippa . In one of these springs, Valvata humeralis is found. Although more widespread in more northern areas of North America, this population probably represents a Pleistocene relict as evidenced by a Pleistocene fossil molluscan fauna in the area.

In upper Railroad Valley, near Duckwater, a totally different molluscan fauna occurs. In the Duckwater Springs, Duckwater Indian Reservation, an undescribed genus-species is found. Besides this spring, Big Warm and Little Warm springs provide habitat for a second undescribed genus-species. Both of these species are different than the species at Lockes Ranch Spring. Although no living specimens were found, an undescribed species of Tryonia also was found in Duckwater Little Warm Spring. No endemic mollusks have been found in springs located on the southern and western slopes of Railroad Valley, except the Lockes Ranch area.

Spring Valley (Shoshone Ponds)

Shoshone Ponds support no endemic aquatic mollusks. Cosmopolitan gastropods such as *Gyraulus parvus* and *Physa virgata* are present. The red rams horn, *Planorbella duryi*, a native of Florida was introduced, but only dead shell has been found. Succineidae, a family of terrestrial gastropods, was found on the soil at the margins of the pond.

Although no endemic freshwater mollusks were found in Shoshone Ponds, endemic hydrobioid snails have recently been discovered in Spring Valley during a systematic molluscan inventory of the valley. One species was found in a spring 8 km south of Shoshone Ponds, as well as in springs located near Cleve Creek, including Grey Spring, which is located on Bureau of Land Management land. Even though the area north of Cleve Creek abounds with springs, the species was not found there.

Pahranagat Valley (Outflow of Ash Springs)

As previously stated, the specific sample site, Burns Ranch portion of the spring run, was dominated by *Melanoides tuberculatus.* Since *M. tuberculatus* is a potential parasite vector it presents a special medical problem. This exotic Oriental snail is a known intermediate host for human trematode flukes. Two of these flukes are *Paragonimus westermani*, which infects the lungs and *Metagominus yokagawai*, which infects the digestive tract. *Paragonimus westermani* is present in North America with one occurrence recorded in man prior to 1964. Frequent occurrences have been reported in mammals in California, among other states.

The introduction of *Melanoides tuberculatus* into the Ash Springs system occurred before 1969, but collections in the headspring in that year yielded only a few specimens. Since 1969, its population has rapidly increased, essentially replacing the native *Tryonia clathrata.* This same phenomenon has been observed in the Muddy River Valley portion of *T. clathrata's* range and with *Tryonia* spp., Ash Meadows, Nevada. Increased utilization of Ash Springs for recreation increases the chances of incidental transport of *M. tuberculatus* to other unique spring systems in Nevada.

Besides *Tryonia clathrata,* the headspring area of Ash Springs supports the endemic *Fluminicola merriami.* It is restricted to Pahranagat

Valley and is found in Ash, Hiko, and Crystal springs. Since *Melanoides tuberculatus* does not occupy their headspring habitat of rocks in moderately flowing water, populations of the native species are in good condition. Any damming of these headsprings would cause a decrease in habitat for the native species, resulting in lower populations.

Steptoe Valley

A brief (24 hour) inventory of aquatic mollusks was conducted in Steptoe Valley in late August. During this period of time, four previously unknown and undescribed hydrobioids were discovered. These were located in springs on the Steptoe and Lazzeti ranches and Shellbourne Pass. This demonstrated just how biologically unknown many of these basins are. In light of these recent discoveries, a more complete molluscan inventory of the Steptoe Valley springs is needed. According to Eakin et al. (1967) there are over 100 springs in the basin.

INTRODUCTION

Relatively few species of fish occur in the Nevada portion of the area being considered for deployment of the M X Missile System. Many species, subspecies and/or populations within this area are of particular concern because they are endemic, endangered, threatened, sensitive, or in some cases, apparently undescribed. The fish fauna throughout a portion of the area has been thoroughly examined by Hubbs et al. (1974). Certain undescribed forms are known to exist in Railroad, Hot Creek, Big Smoky, Fish Lake, and Little Fish Lake valleys, areas not covered by Hubbs et al. (1974). While the undescribed forms are not listed by the Department of Interior in their list of endangered and threatened wildlife and plants, at least some of them do appear on the proposed list of sensitive species developed by the Nevada Department of Wildlife. Nevada is developing a continuing program to clarify both the taxonomic and population status of all native fishes. This effort will initially focus on a few of the forms and populations of uncertain status. In addition to the monograph by Hubbs et al. (1974), general information on population status of many fishes in central and eastern Nevada is available in La Rivers (1962), Deacon (1968; 1979), Deacon et al. (1979), and Hardy (1980a).

This report deals with fishes living in four selected habitats falling within the area proposed for deployment of the M X Missile System in Nevada. Intensive studies were conducted from June through September of 1980 on fishes living in 100 meter sections of Preston Big Spring, Lockes Ranch Spring, and the outflow stream of Ash Spring. In addition, the fish population living in the Shoshone North Pond in the southern portion of Spring Valley was studied in some detail. Fishes involved in these studies include _Gila robusta jordani_ (Pahranagat roundtail chub), _Rhinichthys osculus velifer_ (White River speckled dace), _Catostomus clarki intermedius_ (White River desert sucker), _Empetrichthys latos latos_ (Pahrump killifish), _Crenichthys baileyi_ ssp. (Preston White River springfish), _Crenichthys nevadae_ (Railroad Valley springfish), _Gambusia affinis_ (mosquitofish), and _Cichlasoma nigrofasciatum_ (convict cichlid).

Gila robusta jordani was described by Tanner (1950) from Crystal Spring, Pahranagat Valley, Nevada . It also has been recorded from the outflow of Ash Spring but has not been taken in Upper Pahranagat Lake or south of that point (Miller and Hubbs, 1960; La Rivers, 1962). Records, since 1960, indicate that the species has disappeared from Crystal Spring and its outflow and is, at present, confined to the natural stream course on the Burns Ranch, which is the only relatively unmodified section of stream forming the outflow of Ash Spring. Below Burns Ranch, the outflow becomes confined to a concrete irrigation ditch which contains no suitable habitat for native fishes. Disappearance of _Gila_ from Crystal Spring and its outflow probably occurred prior to February, 1961. Observations and seining at Crystal Spring and its outflow on February 15, 1961 by J. E. Deacon yielded only speckled dace, White River springfish, and carp (_Cyprinus carpio_). Frequent subsequent collections at Crystal Spring have failed to document the occurrence of *Gila* in these waters. The disappearance of *Gila* from Crystal Spring is puzzling, since habitat modifications there appear to be no more severe than those that have occurred in the outflow of Ash Spring, where the species persists in low numbers. Because of the low population, there has been virtually no recent information developed on the ecology of the Pahranagat roundtail chub. Schuman (1978), however, reported on responses to temperature and dissolved oxygen in the closely related forms of the Moapa and Virgin Rivers in Nevada, Arizona, and Utah. The Pahranagat roundtail presently lives in a thermal environment that is very different from other subspecies of *Gila robusta* . The populations from the Virgin and Moapa Rivers have a final thermal preferendum of about 23.8° C. Thermal preferenda shift from about 17-24° C as acclimation temperature shifts from about 8-30° C . Critical thermal maxima shift from about 28-36° C as acclimation temperature shifts from about 10-25° C. The temperature in the area occupied by the Pahranagat roundtail chub is 30-31° C.

Rhinichthys osculus velifer, described by Gilbert (1893) from Pahranagat Valley, where it is common in the outflow of Ash Spring, also occurs in White River Valley, where it is abundant in Preston Big Spring. More detailed examination of variation between the several populations in Pahranagat and White River Valley may reveal additional, as yet undescribed, subspecific differences.

Catostomus clarki intermedius was described by Tanner (1942) from streams and springs at Lund and Preston, White Pine County, Nevada. The subspecies was present in Pahranagat Valley in 1938 but had apparently disappeared from there by 1959 (Miller and Hubbs, 1960). It persists in cold spring flows in White River Valley .

Empetrichthys latos latos was described by Miller (1948) from Manse Ranch, Pahrump Valley, Nye County, Nevada. It exists as a transplanted population in Shoshone Pond, where it has maintained a population since August 31, 1975. Its original habitat is now intermittent. Some information on the ecology and life history of this species has been published by Miller (1948), Deacon et al.(1964), Minckley and Deacon (1968), Selby (1977), Soltz and Naiman (1978) and Deacon (1979). There is, however, no comprehensive account of the life history of the species available. In addition to the work on population size and ecology in Shoshone North Pond done in connection with this study, we also present some information from the files of J. E. Deacon developed many years ago when *E. latos* still occurred in its natural habitat in Pahrump Valley.

Crenichthys baileyi was initially described by Gilbert (1893) from specimens taken in Pahranagat Valley. Williams and Wilde (In press) have recently described several subspecies. One population in Hiko Spring, Pahranagat Valley has become extinct (Deacon, 1979). The populations in Ash and Crystal Springs are now quite low, apparently as a result of competitive interactions with introduced aquarium fish (Deacon et al., 1964; Hubbs and Deacon, 1964; Deacon, 1979; and Hardy, 1980a). Populations in the warm headwaters of the Moapa River are also subjected to population changes, apparently resulting from interaction with introduced fishes (Cross, 1975; Deacon and Bradley, 1972; Hardy, 1980a; and Wilson et al., 1966).

Espinosa (1968) treated spawning periodicity and fecundity in the White River springfish. He demonstrated that spawning occurs primarily in the spring and probably somewhat later in the more northern parts of their range. The spawning season is quite extended however, and there may be a secondary peak in the fall. Size of females at first maturity appears to be larger in populations not subjected to competitive relations with exotic species. This suggests that one possible mechanism of population limitation in the face of competition is to reduce fecundity of the population by becoming sexually mature at a smaller size. On the other hand, the higher fecundity exhibited by the Crenichthys populations at Crystal and Hot Creek springs may represent differences between populations that are unrelated to competitive interactions. Female Crenichthys baileyi produce 6-20 eggs probably twice during the course of a year. Further discussion of spawning periodicity and fecundity in White River springfish is available in Espinosa (1968).

Studies of the physiological and behavioral ecology of Crenichthys baileyi also have shown some interesting variation. The metabolic rate of springfish living in cooler waters is apparently higher (when tested at the same temperature) than it is for springfish from warmer habitats (Hillyard, (In press); Hubbs et al., 1967; Sumner and Sargent, 1940; Sumner and Lanham, 1942). Cool adapted animals were unable to survive the conditions of low oxygen and high temperature occupied permanently by warm adapted animals. Hubbs et al. (1967) and Deacon and Wilson (1967) demonstrated that activity periods of springfish can be influenced by temperature, dissolved oxygen, and the presence or absence of introduced fishes.

The Railroad Valley springfish (Crenichthys nevadae) was described by Hubbs (1932). Hubbs et al. (1967) examined the influence of oxygen concentration and light on activity cycles of the species. Hardy (1980b) comments on a transplant made by the Nevada Department of Wildlife into Chimney Springs in Railroad Valley. He also records the recent introduction of mosquitofish (Gambusia affinis) into the headwaters of Duckwater Spring. Distribution of Crenichthys nevadae is known but most other aspects of its life history have not been examined.

Our studies on the fish focused on determination of population size, population structure, food habits, and habitat preference. Where possible, we have examined historical data in an effort to clarify the probable consequences of M X development in the area.

POPULATION DATA

MATERIALS AND METHODS

Fish were collected at Preston Big Spring and Lockes Ranch Spring during June by shocking 20 meter sections of stream with a 110 volt AC generator. A 15' x 6' x 1/4" mesh nylon blocking seine was placed at the downstream end of each shocking strip and then three consecutive passes were made through the habitat. Fish were removed after each pass and held in buckets. Once a strip had been shocked, fish were measured to the nearest millimeter of total length, the caudal fin was clipped, and the fish returned to quiet water at the downstream side of the area sampled. This procedure was repeated twice over the entire habitat to obtain mark and recapture ratios so that population densities could be calculated by the Peterson method as presented in Ricker (1975). Shoshone ponds, Preston Big Spring, and Lockes Ranch Spring were collected during the study by using minnow traps baited with liver-flavored cat food. Population densities and structure were analyzed by the methods described above. Density of the fish populations at Pahranagat were obtained by direct counting procedures. Both underwater and surface counting were employed in tandem over each consecutive 5 meter section of habitat. Population structure for June only was provided by hand seining selected habitats and recording total length as mentioned above. Length classes were created by combining fish into size intervals of 3 millimeters beginning with 0-1-2 mm total length. This serves to smooth the length-frequency curves somewhat and allows assessment of population structure. Length classes are reported as the median length of a given class interval.

Habitat parameters such as depth, current, substrate, and temperature were taken from the habitat morphometry data and were used to calculate the area sampled, mean depth, mean current, and predominant substrate types for each section of habitat sampled by shocking. Fish data were standardized for these collections by calculating the number of fish per meter squared of habitat sampled. Habitat values specific to trapping locations were recorded at the end of each trap interval and fish densities recorded as number per trap hour for each trap locality. Data were analyzed by comparing the respective densities of a particular species with environmental parameters such as: habitat type, substrate, current, or depth of capture. Statistical analyses were performed by S.P.S.S. (Statistical Package for the Social Sciences). Visual observations were made on all species for reproductive condition and spawning behavior in the habitat. Length-frequency diagrams were used to assess relative age structure of the particular species. Other general observations such as activity cycles, presence or absence of predators, and inter/intra-specific interaction were recorded in the field diary.

Egg surveys were conducted at Preston Big and Lockes Ranch springs during each sampling round by examining various substrates for their presence. Standardized vegetation cores were taken at these springs in September in an effort to quantify the distribution and abundance of the eggs on various substrates and locations within the habitat. Visual feeding experiments were conducted on *Gila robusta jordani* during August and September in an effort to establish food preference patterns.

RESULTS AND DISCUSSION

Preston Big Spring

Rhinichthys osculus

The Peterson population estimate for the June shocking data was 3066 +/- 650. This is in close agreement with the Peterson estimates obtained by trapping in July through September which were as follows: 3985 +/- 300 in July, 2856 +/- 183 for August, and 3210 +/- 211 in September. The August estimate is slightly lower than July but not significantly different from June or September. Table 24 gives summary data for trapping results at this spring and demonstrate that there was no significant difference in the mean number per trap hour for any of these sampling periods. Figure E-1 demonstrates a shift in population structure during the summer sampling period. The shift appears to be largely due to growth of individuals in the population sampled in June. Little evidence exists of recruitment of a significant number of young of the year subsequent to June. Some fry and fingerling dace were observed during all four sampling periods.

Dace consistently showed a significant reduction in number per trap hour below transect 50 during each sampling round. This is primarily a response to significantly higher current speeds in this area of the habitat. The electivity curves for the response of dace to current and depth are given in Figures E-2 and 3. In general, as current speed increased and depth decreased, the number per trap hour declined. This pattern held true for each sampling round. Significantly higher numbers per trap hour were collected in the marginal habitats during each sampling round. This reflects a response to differences in current speed and available cover. Dace showed no preference to any substrate. Since temperature and oxygen levels were so consistent throughout the habitat, no significant difference in dace distribution resulting from variability in temperature or oxygen could be discerned.

Examination of available substrates for eggs during September was unsuccessful within the study area but several were found adhesive upon *Utricularia* sp. 200 meters down the outflow. Fry and fingerling were most common during June through August though many were still evident in September. They were entirely confined to the extreme lateral quiet waters of the stream course where dense mats of emergent *Scirpus* sp. and watercress provided adequate cover. Several collections within each sampling round showed that young dace were consistently the most abundant in these microhabitats. There were no specific recordings of actual spawning behavior during our investigation though breeding colors were persistent from June through August. The number of individuals with breeding colors had greatly diminished in the September collections. Dace exhibited schooling behavior throughout the study and could be observed feeding on drift as well as "diving" into algal mats or other aquatic vegetation. Dace did not show any aggressive behavior toward *Crenichthys baileyi* but did move out of areas occupied by *Catostomus clarki*.

Historical data collected at this spring by Dr. James Deacon in 1965 and 1966 showed that the White River springfish, *Crenichthys bailevi*, was the most abundant species and that the speckled dace was the second most dominant species. Our study shows that the speckled dace and springfish have reversed their dominance but that the total number per meter square of all fish has remained unchanged. This suggests that the total carrying capacity of this system has remained stable over the last 15 years. Deacon's data also demonstrated that the mean number of dace per meter square also decreased below transect 60. This again is primarily a response to higher current speeds and reduced available cover. The severe habitat alterations discussed under habitat morphometry apparently did not affect the dace population.

Crenichthys baileyi

The use of shocking gear at this spring in June apparently resulted in selection against springfish. Their utilization of heavily vegetated areas did not permit adequate sampling and the variance associated with the population estimates gave unreliable results. The number of captures were so low that further statistical treatments were not possible for this data set. The use of traps during subsequent sampling periods proved adequate in obtaining sufficient numbers of springfish to allow a statistical analysis of population size. The Peterson population estimates for the July through September data are as follows: 1674 +/- 240 in July, 1202 +/- 251 in August, and 1380 +/- 470 in September. There is no significant difference between the estimates. There was also no significant difference in the mean number per trap hour during the July through September sampling (Table 24). Figure E-4 demonstrates that a shift in population structure did occur during the summer sampling period. In general, as the summer progressed, the percentage of larger fish in the sampler decreased while the percentages of smaller fish increased. This pattern demonstrates that recruitment and growth were occurring throughout the summer and that there was probably post-reproductive mortality in the adult population.

Springfish showed a consistent drop in the mean number per trap hour below transect 60 for all of the collections. As with the speckled dace, this is a response to both significantly higher current speeds and lack of calm water with dense mats of aquatic vegetation. This also accounted for significantly higher densities along the western and eastern boundaries of the spring where quiet water refugia are well developed. Figure E-5 and 6 show the response of springfish to current and depth for all the collections. This pattern was consistent for each of the sampling rounds. Springfish showed a slight preference for softer substrates which are only found in the quiet, slow current portions of the habitat (Table 24).

Spawning behavior was not observed during the course of field studies though breeding colors were noted during all sampling rounds. Examination of extensive quiet water areas during all months resulted in observations of only a few springfish fingerling and fry. The reproductive success in this species was notably less than that of the speckled dace during June through September, 1980. Whether this has resulted in a lower population size than occurred in 1965-66 is unknown. We suspect, however, that habitat factors are involved in the observed reversal of dominance, rather than changes in biological characteristics of Crenichthys baileyi. Springfish were not observed integrating with schools of speckled dace and were often seen moving out of an area when approached by other species. Often a vast majority of a single trap catch would be dominated by a

Table 24. Summary statistics for trapping data at Preston Big Spring, July through September, 1980. Means and standard errors are in number per trap hour. An * indicates a significant difference at the 95% confidence interval.

Crenichthys baileyi				*Rhinichthys osculus*			
PARAMETER	MEAN	STD. ERROR	N	PARAMETER	MEAN	STD. ERROR	N
				SUBSTRATE			
mud	8.9*	2.1	12	mud	35.5	9.0	12
sand	2.6	0.6	9	sand	11.2	2.8	9
sand/mud	7.0*	1.2	27	sand/mud	26.9	6.2	27
sand/gravel	2.9	0.7	66	sand/gravel	10.2	1.6	66
rock/gravel	1.4	1.1	6	rock/gravel	14.9	7.1	6
unidentified	8.3	3.6	3	unidentified	27.2	8.2	3
				DATE			
July	4.7	0.8	51	July	12.1	2.1	51
August	5.5	1.3	36	August	18.2	3.4	36
September	3.0	0.7	36	September	23.0	5.1	36
				TRANSECT			
tran. 20	9.6	2.6	9	tran. 20	25.1	6.3	9
tran. 35	7.4	2.0	9	tran. 35	12.5	3.7	9
tran. 50	5.2	2.2	9	tran. 50	10.0	1.9	9
tran. 65	3.4	1.3	9	tran. 65	13.8	7.9	9
tran. 80	0.4	0.2*	9	tran. 80	7.5	3.0	9
tran. 95	0.5	0.3*	9	tran. 95*	1.9*	0.5	9
				TRAP LOCATION			
east edge	3.8	1.1	18	east edge	14.1	5.2	18
middle	2.6	1.0	15	middle	11.6	3.1	15
west edge	7.2	1.8	18	west edge	10.5	1.7	18

single size class. This may indicate that only fish of similar size (age) school together. No specific observations of feeding behavior were made in springfish, primarily due to their utilization of dense cover most of the time.

Visual observations during September, suggested that the habitat modifications by cattle may have had a detrimental effect on the springfish. Fewer specimens were observed and there did not appear to be as many individuals in the traps. However, statistical analysis showed that there was no difference in either numbers per trap hour or population estimates from previous months.

To our knowledge, Crenichthys baileyi continues to exist throughout its known historical range with the exception of Hiko Spring, where it has been extirpated. Several other populations are considerably diminished in size as a result of habitat modifications and introduction of exotic species by man. Additional information on the status of Crenichthys baileyi populations is available in Hardy, 1980; Deacon, 1980; Deacon, et al. 1979; and Williams and Wilde, (In press).

Lepidomeda albivallis

Historical data collected during 1965-66 indicated that this species was not common but that specimens were regularly collected. Extensive shocking in June and trapping and hand seining in July through September failed to produce a single specimen. The loss of this species is probably a result of the diversion of the outflow into underground pipes and habitat disruptions throughout the remainder of the spring system. Visual observations at a spring just southwest of Preston Big Spring did not produce any sightings of this species. Lund Town Spring is currently the only known habitat still retaining the spinedace in Upper White River Valley. The presence of specimens in several other springs in the vicinity of Preston has not been confirmed within the last 10 years. Further field reconnaissance is recommended for this species.

Catostomus clarki

Very few specimens of the White River sucker were observed within the study area during any of the sampling rounds. Visual counts ranged from just over 20 in June to less than 5 in September. Extensive shocking and hand seining on several occasions failed to produce any young of the year or more than a few adults from the entire spring. The population of suckers in this spring is certainly below 50 and may be considerably lower. This species could become extirpated at Preston Big Spring within the next few years.Efforts should be initiated immediately to assess the current distribution and population status of the remaining populations within the upper White River Valley. Collections by Deacon in 1965-66 indicate that this species was more abundant at that time. Lund Town Spring currently contains a small population of suckers. This is the only spring within this valley that has been checked in the last few years. Further work is necessary to assess the status of this species over its current range. Reasons for the decline in Preston Big Spring are probably similar to those listed under Lepidomeda albivallis.

Lockes Ranch Spring

Crenichthys nevadae

The Peterson population estimate for the June shocking data was 11393 +/- 4700 and is in close agreement with the July trapping data which yielded an estimate of 12788 +/- 2500. Both of these estimates are somewhat higher than the August and September trapping estimates which are as follows: 7309 +/- 1156 in August and 7792 +/- 822 in September. The discrepancy in the estimates may result from relatively low recapture rates in the first two samples, from high mobility of this species in the system, or from a tendency of the species to occupy downstream marshy or slower water habitats during the summer but rely more strongly on warmer headwater areas during winter and spring. There were increasing mean numbers per trap hour in the July through September trap samples with September showing a significantly higher trapping success rate than the previous two months (Table 25). The increased trap catch in September, with a lower population size than existed in July, is puzzling. Perhaps for some reason the springfish tend to move more extensively in the fall of the year than during the summer. If so, it would be consistent with the suggestion made above that they rely more strongly on (and therefore tend to move into) the warmer headwaters habitat in the winter.

Figure E-7 illustrates the population structure for springfish during the summer from June through September. This length-frequency figure indicates that reproduction and recruitment into the adult population is occurring consistently. The presence of young in these samples shows that spawning activity has been going on for several months and is continuing. It is apparent in Figure E-7 that young were more prominent in the population in June than was true later in the summer. It also appears that adult mortality was greater in September than earlier in the summer. This suggests that even though there appears to be an extended spawning season in this constant temperature spring, spawning intensity increases in the spring. Eggs were located along the margins of the Scirpus beds throughout the study site during all months. They were found almost exclusively on Utricularia sp. The highest densities of eggs were found at transects 95-100 on the east and west margins of the spring channel where extensive shallow areas supported well developed mats of Utricularia. No spawning activity was observed during the course of our observations. Eggs appeared to be more abundant in June than in September. This impression is consistent with benthic invertebrate data (Appendix C), where egg collections were included in the analysis.

In general, springfish showed increasing densities as one moved down the outflow from the spring pool. This pattern was consistent for each of the sampling rounds and is a consequence of several factors. The availability of shallow, marginal habitats with aquatic macrophyte growth increases significantly as one proceeds down the outflow. At these lower transect locations, from 30 through 100, the fish utilized all areas of the stream course. However, at the spring pool, fish congregated along the margins of the Scirpus beds where a boundary layer of cooler water with higher oxygen levels is associated with the emergent vegetation. Fish, when released into the main pool after having been in the trap for a period of time, would often surface and expose the dorsal aspect of their head while ventilating their gills at the air/water interface. This

Table 25. Summary statistics of trapping data for Crenichthys nevadae at Lockes Ranch Spring, July through September, 1980. Means and standard errors are in number per trap hour. An * indicates a significant difference at the 95% confidence interval.

PARAMETER	MEAN	STANDARD ERROR	N
SUBSTRATE			
mud	13.3	3.1	57
travertine sand	18.6	2.3	96
DATE			
July	10.4	2.4	68
August	15.4	2.5	48
September	29.8*	4.8	37
TRANSECT			
tran. 5	7.2	1.5	30
tran. 15	12.6	3.8	15
tran. 25	12.0	4.2	11
tran. 30	12.5	9.6	8
tran. 35	21.7	7.1	7
tran. 40	2.1	1.0	4
tran. 45	31.3*	7.6	8
tran. 50	7.6	1.3	8
tran. 55	7.6	2.0	7
tran. 60	2.4	0.5	4
tran. 65	32.2*	8.5	7
tran. 75	16.7	7.2	15
tran. 85	22.1	7.6	11
tran. 95	35.9*	10.9	14
tran.100	39.1	18.2	4

behavior continued for several seconds before the fish would seek refuge in the cooler, more oxygenated waters in the aquatic vegetation. Oxygen concentrations also tend to increase and temperatures decrease downstream, especially in the quiet marginal habitats. These facts account for the significantly higher densities of springfish along the margins of the spring outflow rather than in mid-channel for all of the sampling rounds. The response of springfish to current and depth can be found in Figures E-8 and 9. In general, as current speeds increase, densities decreased. The response to depth is bell-shaped and demonstrates avoidance of shallow water with high current speeds, as well as deep waters in the main pool when temperatures are high and oxygen is low.

Feeding behavior was observed on many occasions during the course of our field collections. Springfish would often dive into and pull vigorously on strands of algae, as if specifically in pursuit of selected prey items. Many times, the fish apparently were feeding on drift, although no specific food items could be discerned.

ShoshoneNorth Pond

Empitrichthys latos latos

The Peterson population estimates for June through September are as follows: 1148 +/- 116 in June, 918 +/- 95 in July, 817 +/- 81 in August, and 952 +/- 90 in September. These estimates represent a very stable population. Stability is also evident in the population structure as presented in Figure E-10. There is no significant difference (.05) between any of the months, though a slight shift to the right in the percentages of larger fish does indicate growth over the summer sampling period. September data are not presented due to the high incidence of previously clipped caudal fins in the sample. There was no significant difference in the mean number per trap hour during any of the months sampled.

Since the initial introduction of 50 killifish in August, 1976, the population has only received sporadic monitoring. Population estimates conducted on April 26-27, 1977, showed that the population had increased 684% to 392 individuals (Logan, personal communication, 1977). By October 27, 1977, the population had increased to 702 (Selby, personal communication, 1977). "Status" of the population was reported by Hardy (1979) but no population estimates were available. The density of killifish demonstrated here suggests that the population may, by October, be very near the level estimated by Selby. This further suggests that the species expanded to about long-term carrying capacity within its first year of existence in Shoshone North Pond. Length-frequency analysis performed on the June through August data, indicates that reproduction and recruitment occurred prior to June. Spawning probably takes place in March or April. We did not observe spawning behavior or fry in our June - September sampling at Shoshone North Pond. The fact that the killifish did not show any preference pattern related to depth (synonymous with trap location) in the pond is consistent with field observations made on this species in its native habitat at Manse Ranch, where it utilized all areas of the spring (Selby, personal communication, 1976). Deacon's observations at Manse Spring in 1961-67, however, suggested a slight preference for the deeper water habitats. Studies by Selby indicated that in transplanted populations the young are more active during the daylight hours and the adults are more active at night (ibid). The trapping data collected by our group did not show this trend but this may be a result of the absence of very young fish.

Outflow of Ash Spring

The visual counts for all species during each sampling round can be found in Tables E-1 through E-4.

Gila robusta jordani

The chub population found within the study area during the June through August sampling rounds was fairly stable and contained a large percentage of young of the year. No discernable change could be detected in the adult population over the summer, however, young of the year almost completely disappeared from the September counts, causing a dramatic decline in the total population. Whether these individuals moved further upstream or died is, as yet, undetermined. At this time, the success of recruitment into the adult population cannot be judged, but winter mortality of the young chubs must be high, since there are so few large adults in the population. Young chubs, prior to September, made up over 90% of the total population estimated to be under 250 individuals. The September estimates are about one half this number.

Adult chubs were only found in a deep hole with undercut banks at station 50. Adults were never observed in the shallow runs on either side of this habitat and only ventured a few meters from under the bank, during foraging behavior. Juveniles and young of the year were observed throughout the entire 100 meter section but were in their highest density in the deep hole at station 50. The smaller specimens, about 21 mm in total length, could be observed in schools with speckled dace in the deeper portions of the stream. Solitary individuals or schools of up to 10 specimens could be found in the swifter, shallower areas of the stream but were very mobile, preferring the cover of undercut banks and snags with a heavy growth of periphyton. Most observations of young chubs were made in the deeper sections of the stream and none were found in the shallow quiet water where mollies and mosquito fish reach their maximum densities. Solitary individuals were the exceptions with schools ranging from 3 to 15 individuals. Larger schools of more than 25 individuals occasionally were seen in the hole at station 50. Frequently, chubs were observed schooling with speckled dace. Some of the adult chubs still retained breeding coloration in August, though no spawning attempts were observed. Careful examination of extensive shallow, slow current areas failed to reveal any larval chubs. This suggests that peak reproduction occurred prior to June. A majority of the young chubs were in the range of 30 to 100 millimeters in total length. Some individuals ranged in size up to 200 mm and undoubtedly are two or more years old. Several of the larger adults were over 300 millimeters in total length.

Feeding experiments conducted in August and September showed conflicting results for food preference patterns. Visual observations made on the chubs clearly revealed that they feed on drift and would often be seen darting at passing "items" which were sufficiently small that they could not be observed even with close-up underwater movies. Several taxa of aquatic invertebrates were released into the chub hole at transect 50 both in August and September. Chubs ignored such potential food items as odonata nymphs and adults, adult molluscs, and injured larval fish. Terrestrial adult dipterans, however, were taken approximately 40% of the time. The presence of a diver in the water and/or the lights attached to the underwater camera may have inhibited the chubs in their feeding response. The animals did not show any fluctuations in their activity patterns during any of the observation rounds.

Rhinichthys osculus

The speckled dace was the most abundant native species during June and July. The August and September counts showed a dramatic decline like that observed in the chubs. Again, the reason is, as yet, undetermined. Figure E-11 shows the population data obtained from the June collections. This figure demonstrates that reproduction had occurred prior to this sampling round. There were few observations of any individuals in breeding color in June through September, suggesting that reproduction had already occurred. No spawning behavior was observed. Dace were only occasionally observed in shallow sections of the habitat and preferred the deep, vegetated banks. Again, as with the chubs, solitary individuals were the exception. Dace were commonly found in groups of 3 to schools of 60 or more, oriented upstream behind well-developed snags and protruding banks. They did not appear to mind the presence of young chubs of similar size classes but would move when a larger fish of any species came close. Feeding was observed on many occasions and was primarily oriented toward drift. Some individuals were observed diving into algal mats, apparently after potential food items.

Crenichthys baileyi

The White River springfish was only observed on three occasions. Its occurrence in this section of the stream may be "accidental". Its highest densities occur within the spring pools and their immediate outflows. Since the introduction of mollies and cichlids in 1964, populations of springfish in spring pools have declined dramatically, Hubbs and Deacon (1964), Deacon and Wilson (1967). While springfish densities in this outflow were probably never high, some evidence suggests it was formerly more common than now. It is interesting to note that in May of this year, a male springfish was observed attempting to mate with a mexican molly. This misplaced reproductive effort may have contributed to the reduction in springfish population size following introduction of the molly.

Gambusia affinis

This species was almost entirely confined to the quiet waters at the shallow edge of the stream in and around transects 55 through 60 and 25 through 40. The mosquitofish was never observed utilizing mid or bottom waters and rarely ventured more than a meter away from the sides into swifter current. Mosquitofish are probably underestimated by our visual counts because some shallow areas occupied by this species could not be viewed adequately.

This species along with Poecilia mexicana have a high potential to impact the native fish in this system. Because of its utilization of the extreme lateral habitats and their known carnivorous habits, predation on larval fish is almost a certainty. At no time in our field studies did their reproductive effort appear to decline. Young were always numerous and spawning behavior was common during all times of the day. The feeding response of this species was very aggressive to any surface disturbance and "swarming" was common.

Poecilia mexicana

The shortfin molly, since its introduction in 1964, has become the second most abundant species in this system. The highest densities occurred in the quiet shallow areas where it occupied the mid and bottom portions of the water column. In the swifter portions of the stream it was observed along the bottom in and about the aquatic vegetation. Mollies almost always occurred in schools of 5 or more and intensely pursued food items introduced into the water. Spawning behavior was observed continually throughout the study. Most of the quiet water areas were saturated with young and it is important to note that even a minor reduction in water would result in dense concentrations in the remainder of the available habitat. This occurs intermittently at present as a result of irrigation diversions upstream from the study area. This may be one factor preventing mollies from becoming the most abundant species in the habitat.

Cyprinus carpio

Several adult and young carp were observed in and about the study area during all of the sampling rounds. These fish did not tolerate the presence of people in the water and would move out of an area immediately when we entered the water. They were not observed to return to the habitat after the initial movement. Little direct observation was therefore possible on their influence with the other species in the system. The fact that it is an exotic and reproducing, suggests that it is competing for both space and food resources.

Cichlasoma nigrofasciatum

The convict cichlid was introduced into this system around 1964 and has expanded to become the most numerous and widespread of any fish species. Their nesting behavior and aggressive protection of the young has undoubtedly led to this success (Tables E-1 through 4). In June through September, the study area supported an average of more than 1 nest per square meter. Nests were not only vigorously defended against other cichlids but against other species as well. Young of the year were numerous during all collections and all size classes were represented in the population.

In general, the cichlids did not demonstrate a preference for a particular habitat type, although the highest densities were usually in shallow, calm water. The largest adults utilized very swift water in the main channel on a regular basis, although many could still be observed in the shallows. Cichlid schools were common during both months and would usually contain a relatively uniform size distribution within a given school. Fish less than 21 millimeters in total length were never observed out of the nest. Fish larger than this could be seen venturing a fair distance but when disturbed, would immediately dive into the filamentous algae beds. Current speeds did not appear to be a limiting factor in the upstream distribution of cichlids. They were the most common species observed in the habitat from the wooden bridge, upstream to the confluence of Ash and Crystal Springs outflows.

FOOD HABITS ANALYSIS

MATERIALS AND METHODS

Food habits were determined for eight species of fish collected once a month during summer, 1980 from four spring systems in Nevada. Fish were collected as follows from Preston Big Spring: Rhinichthys osculus velifer (June through September), Crenichthys baileyi subsp. (June through September), and Catostomus (Pantosteus) clarki intermedius (June and July); Big Spring at Lockes Ranch: Crenichthys nevadae (June through September); Ash Springs: Rhinichthys osculus velifer (June through August), Gambusia affinis (September), Poecilia mexicana (June through September), and Cichlasoma nigrofasciatum (June through September). In addition, data from the files of J. E. Deacon on stomach contents of Empetrichthys latos latos collected from Manse Spring during 1961 to 1963 are presented.

Fish were preserved in 10% formalin, then transferred to alcohol prior to examination. Standard length, total length, and intestine length were measured to the nearest 0.1 mm with precision calipers for specimens from Preston Big Spring and Big Spring at Lockes Ranch. These characters were measured to the nearest 1 mm for specimens from Ash Spring. Peritoneum color and intestine configuration were noted for specimens examined. Intestinal contents from esophagus to anus were examined for all species except Catostomus clarki intermedius for which the anterior section of the intestine from the esophagus to the end of the first intestinal loop was analyzed. Determination of intestinal contents was made with a 7X - zoom binocular microscope. Data from intestine contents were divided into percent animal, percent plant, and percent detritus components. Detritus was defined as any inorganic material. Percent frequency of occurrence, mean number per intestine, mean percent volume, and a value of relative importance was reported for each food. Percent frequency of occurrence was defined as the number of intestinal samples in which one or more of a given food item was found, expressed as a percentage of all nonempty intestines examined (Windell and Bowen 1978). The total number of a given food observed in the intestines, divided by the number of nonempty intestines examined, was the mean number per intestine. Mean percent volume was defined as the total volume estimated for a given food divided by the number of nonempty intestines examined. Percent volumes were determined by separating the intestine into two or more subsamples and visually estimating the percent contribution of a given food in each sample. The percent contribution of each subsample to the contents of the entire intestine was estimated so that the volume of a given food relative to all intestinal contents could be determined. Percent frequency of occurrence, mean number per intestine, and mean percent volume each contain a bias which limits their usefulness when used separately (Windell and Bowen 1978). For example, percent frequency of occurrence overemphasizes the importance of small food items that may be ingested frequently but have a small impact on the volume of food in the intestine, whereas the mean percent volume may overemphasize those foods which are large, but occur less frequently. To minimize these biases, an index of relative importance (RI) is reported for each food. This index combines the percent frequency of occurrence and mean percent volume for food "a" into an absolute importance index (AIa) as follows:

$$AIa = \%\ \text{frequency of occurrence} + \text{mean}\ \%\ \text{volume}$$

The absolute importance index is then used to calculate a relative importance index as follows:

$$RIa = (100)\ AIa \Big/ \sum_{i=1}^{n} AIa \quad \text{where } a = 1$$

here n is the number of different foods. Determination of RIa and AIa are by methods modified from George and Hadley (1979).

Selectivity for a given food was determined by comparing the abundance of the food in the intestines and in the habitat. This selectivity is reported as an Index of Electivity (E), defined by Ivlev (1961) as follows:

$$E = (ri-pi)/(ri+pi)$$

where ri is the percentage composition of a particular, food in the intestine and pi is the percentage composition of a particular food in the environment. The index has an absolute range of -1 to +1. Thus an Electivity value of -1 represents a high negative selection, whereas a value of +1 suggests high selectivity for a given food. A value of 0 indicates no selection but instead suggests feeding based on food abundance in the environment. Values of pi and ri are percentages determined from the numbers of invertebrates sampled in each case. The value for pi is derived by combining all invertebrate samples at a given spring.

In addition to determining selectivity by the Index of Electivity, the Linear Index (L) of Strauss (1979) is presented and defined as follows:

$$L = ri-pi$$

wnere the components ri and pi are defined as in the Index of Electivity. Some of the advantages of the Linear Index are as follows: (1) the index is distributed approximately normally, (2) the measure takes on extreme values only when a food is rare but consumed exclusively or is very abundant and rarely consumed, (3) it is defined for all values of ri and pi, and (4) the sampling variance is defined to allow statistical comparison of two calculated values or to a null hypothesis value.

Invertebrate identification is based on Pennak (1978).

RESULTS AND DISCUSSION

Preston Big Spring

The availability of potential foods within the habitat are given in Figures F-1 through 4. Results of the food habits analyses for the three species from Preston Big Spring are given in Figures F-5 through 14.

Rhinichthys osculus velifer

Speckled dace from Preston Big Spring were primarily carnivorous in June, July and August, when animal matter comprised 57, 70, and 54 mean percent volume, respectively (Figures F-5 through 7). However, during September, speckled dace were herbivorous, consuming large amounts of diatoms and filamentous algae (Figure F-8). Plant material accounted for 59 mean percent volume of intestinal contents during September.

In June and July, when the speckled dace were carnivorous, Oxyethira, a hydroptilid trichopteran, was a main food. The mean percent volume of Oxyethira was 29 and 41 in June and July respectively, resulting in relative importance values of 19 and 32 (Table 1 and 2). In August, the dace fed primarily on unidentified aquatic insects (RI = 21) and various life-stages of Diptera, mostly chironomid larvae (Table 3). Indices of selectivity (Table F-4) indicate that hydroptilids were selected for in June and July (E = 0.58 and E = 0.60, respectively) but strongly selected against in August (E = -1.00). Chironomids were selected for most strongly during August (E = 1.00). In June, July, and August, plant material contributed less than one-fourth of the mean percent volume in intestines with filamentous algae comprising most of the plant material.

September showed a distinct change in the food habits of the speckled dace examined (Table F-5). The herbivorous food habit observed in September was dominated by ingestion of diatoms (RI = 27), which contributed 41 mean percent volume, and filamentous algae (RI = 16), which contributed 17 mean percent volume. Hydrozetes, a water mite, was the most important animal food in September (RI = 13), occurring in 60 percent of the intestines examined and contributing 4 mean percent volume. Oxyethira, a major food in June and July, contributed 5 mean percent volume in September. The main animal foods of August had small contributions to intestinal content in September.

The shift in food habits from carnivory in June, July, and August, to herbivory in September, is coincidental with increased grazing by cattle around the spring habitat prior to the September collection of fish. Increased cattle grazing caused the disappearance of emergent vegetation along the edges of the Preston Big Spring habitat. The removal of emergent vegetation stimulated diatom and filamentous algae growth by allowing increased sunlight to reach the water. Field observations showed a definite increase in the abundance of these plants in September. Loss of emergent vegetation decreases the habitat available to many aquatic invertebrates, and therefore, may have simoultaneously decreased some invertebrate population numbers. Oxyethira abundance was greatly depressed in September because of emergence. Decrease of this important food may have forced the change in food habits observed in Rhinichthys during September.

The intestine length to standard length ratio was near 0.9 in speckled dace from Preston Big Spring. An intestine length less than, or equal to, standard length indicates a carnivorous feeding habit (Odum, 1970). These fish also lacked the black peritoneum associated with herbivores, instead, possessing a silvery-colored peritoneum. These characters are in contrast to the large volume of plant material consumed during September and may be indicative of a lack of preferred foods in

Preston Big Spring at that time.

Crenichthys baileyi

The springfish from Preston Big Spring were omnivorous in June, when plant material comprised 37 percent of intestinal volume and animal matter comprised 21 mean percent volume. In July, August, and September, the fish were primarily herbivorous, consuming 58, 57, and 58 percent plant material by volume, respectively (Figures F-9 through 12).

Filamentous algae (RI = 32) was the most important food in June, contributing 24 mean percent volume and occurring in over 60 percent of the intestines examined (Table F-6). Trichoptera were the most important animal food. Oxyethira larvae, comprising 9 percent intestinal volume, was the most important Trichopteran (RI = 10). Data from Table F-4 on food selectivity indicate Oxyethira is strongly selected for by Crenichthys in June (E = 0.64, L = 0.69).

In July, filamentous algae (RI = 42) was the most important food, contributing 48 mean percent volume and occurring in all intestines examined (Table F-7). Oxyethira was, once again, the most important animal food, contributing 5 mean percent volume. Fish scales were of some importance in July (RI = 6). Crenichthys is aggressive, and it is possible for the fish scales to have been ingested from either the body of a dead fish found in the bottom sediments or during a show of aggression toward another individual. Chironomids were also an important animal food in July (RI = 7). Indices of selectivity indicate that chironimids were selected for and trichopterans were selected against by Crenichthys in July (E = 0.36, and E = -0.26, respectively).

Filamentous algae and diatoms were of primary importance in August, contributing 21 and 24 mean percent volume, respectively (Table F-8). Higher plant was also a major food comprising 12 mean percent volume. Oxyethira contributed the largest mean percent volume of any animal food in August, contributing 9 percent, but was ingested by only 10 percent of the fish examined. Hydroptilids and chironomids were both selected for by Crenichthys in August (E = 0.89 and E = 0.69, respectively).

In September, Crenichthys consumed only 5 mean percent volume animal matter, with insect eggs and Oxyethira the predominate animal foods (Table F-9). Filamentous algae was the most important food (RI = 36) occurring in 90 percent of the intestines examined and contributing 20 mean percent volume. Amorphous plant material was the second most important food (RI = 28). This food was very important to Catostomus. Crenichthys in September were the only other fish examined that ingested amorphous plant material.

The mean ratio of intestine length to standard length is slightly greater than one, a value borderline between omnivory and carnivory (Odum, 1970). Peritoneum color in Crenichthys is jet black, a color correlated with herbivorous feeding by Smith (1966). Food habit analysis suggests the fish are primarily herbivorous.

Catostomus clarki intermedius

Catostomus from Preston Big Spring were herbivorous in all months examined (Figures F-13 and 14). Plant material comprised 99 mean percent volume in June, and 89 mean percent volume in July. No animal matter was ingested in either month.

In June, the most important food was amorphous plant material, with a relative importance index of 84 (Table F-10). Filamentous algae (RI = 16) was the only other food ingested, contributing ten percent intestinal volume.

A slight increase in diversity of foods utilized was seen in July (Table F-11). Amorphous plant material (RI = 57) was the most important food. This food was observed in all fish examined and comprised 64 mean percent volume. Diatoms were also an important food (RI = 35), contributing 21 mean percent volume. Diatoms were observed in 80 percent of the intestines examined. Filamentous algae and higher plants were each observed in small amounts in one fish resulting in a relative importance index of 4 for both foods.

The ratio of intestine length to standard length was approximately 5.5, indicating herbivory (Odum, 1970). The dark peritoneum color observed in Catostomus is also indicative of the herbivorous feeding habits of this fish.

Indices of selectivity calculated for various animal foods further exemplifies the strict herbivory of Catostomus (Table F-4).

Lockes Ranch Spring

The availability of potential foods within the habitat is given in Figures F-15 through 18. Results of the food habits analysis for the Railroad Valley springfish are given in Figures F-19 through 22.

Crenichthys nevadae

The railroad Valley springfish was predominately carnivorous in all months. Animal foods comprised 64, 88, 68, and 65 mean percent volume in June, July, August, and September, respectively (Figures F-19 through 22). Plant material was important in June, contributing 26 mean percent volume, in July, August, and September, however, only a small percentage of intestinal volume was occupied by plant material.

Gastropods (RI = 32) were the most important foods in June, comprising 54 percent intestinal volume (Table F-12). Ostracods (RI = 15) and fish scales (RI = 11) were also important foods. Most of the plant material ingested by Crenichthys in June was filamentous algae, which had a relative importance index of 23. Filamentous algae contributed 20 mean percent volume. Indexes of selectivity indicate that gastropods and ostracods were selected for by springfish in June (E = 0.34 and E = 0.78, respectively) (Table F-13).

In July, ostracods were the most important food (RI = 57). Ostracods were found in all intestines examined, comprising 83 mean intestinal volume (Table F-14). There were an average of 401.8 ostracods per intestine. Chironomid larvae (RI = 16) occurred in 50 percent of the intestines examined, comprising 3 mean percent volume. Gastropods were not a major food in July, occurring in ten percent of the intestines examined and contributing only 2 mean percent volume. Filamentous algae was the most important plant material ingested, contributing 4 mean percent volume. Ostracods were highly selected for (E = 0.98), but chironomids were selected against (E = -0.83) during July. No data was available on the contribution of gastropods to the environment in July, so calculation of a selectivity index was not possible for this food.

Ostracods were the most important food in August (RI = 36), comprising 43 mean percent volume (Table F-15). Amphipods and chironomid larvae were also important foods, with relative importance indexes of 11 and 21, respectively. Filamentous algae was the primary plant material ingested, contibuting 9 mean percent volume. An electivity index of 1.00 indicates that ostracods were a preferred food in August.

In September, ostracods continued to be of great importance (RI = 29) contributing 26 mean percent volume (Table F-16). The Electivity Index once again indicated high selection for this food. Hydrobiid snails (RI = 19) were also an important food, comprising 18 mean percent volume. Filamentous algae was the most important plant material (RI = 18).

The ratio of intestine length to standard length was 1.3 for Crenichthys nevadae examined, indicating omnivory (Odum, 1970). The predominately carnivorous feeding behavior is in contrast with the black peritoneum color observed. According to Smith (1966), a black peritoneum corresponds with herbivory in catostomids. Other workers have expanded this logic to other fishes. Perhaps the high temperatures in the habitat sampled demands consumption of higher energy animal foods than would be necessary at lower temperatures.

Shoshone North Pond

The availability of potential foods within the habitat are given in Figures F-23 through 26. Results of the food habits analysis for the Pahrump killifish collected from Manse Spring during 1961-1963 are given in Table F-17.

Empetrichthys latos latos

The diet of the Pahrump killifish, in the now dry spring pool at Manse Ranch, Pahrump Valley, Nevada, consisted primarily of a mixture of insects, snails, and other invertebrate animals comprising 32 mean percent volume (Figure F-27). A large percentage of the intestinal volume was occupied by debris of a fibrous or gelatinous nature. Plant matter contributed only 2% to the mean intestinal volume.

Insects were the most frequently eaten animal, contributing 26 mean percent intestinal volume. Snails, including Physa and hydrobiids, contributed 5 percent to intestinal volume (Table F-17). Eggs comprised 3 mean percent volume.

Macroinvertebrate samples indicate that gastropods were abundant in the littoral vegetation (63%) and bottom mud (50%) of Shoshone North Pond in June (Figure F-23). Since snails were utilized by the killifish at Manse Ranch, they probably constituted an important food source for this species in Shoshone North Pond in June. The larger zooplankton are probably also an important food source. The relative scarcity of copepods and cladocerans in the open water zooplankton (5%) and their relative abundance (16%) within the algal mat community in June, strongly suggests that these are eaten by killifish when they leave the algal mat community. Macroinvertebrate samples taken in July, indicated a greater diversity of macroinvertebrates than seen in June (Figure F-24). Chironomids and ephemeropterans were probably important foods in July. In August, Coleoptera were more abundant and were probably an important food (Figure F-25). Gastropods, cladocerans, dipterans, and ephemeropterans were also fairly abundant in August, and were therefore, probable foods. Odonates were predominate in macroinvertebrate samples collected in September (Figure F-26). Coleopterans and dipterans were also abundant and were probably important foods. The Odonata of Shoshone North Pond are probably not an important food resource for killifish.

Outflow of Ash Spring

The availability of potential foods within the habitat are given in Figures F-28 through 31. The results of food habits analyses for the fishes inhabiting the outflow of Ash Spring are given in Figures F-32-43.

Rhinichthys osculus velifer

In all months for which intestines were examined, speckled dace were primarily carnivorous, with animal matter comprising 74, 64, and 73 mean percent intestinal volume in June, July, and August, respectively (Figures F-32 through 34). Plant material was normally an insignificant component of the diet except, during July, when plants comprised 12 mean percent volume.

Chironomid larvae were the most important food in June (RI = 41) and July (RI = 20), and the second most important food in August (RI = 16) (Tables F-18 through 20). Trichoptera were the primary food in August, accounting for 40 mean percent volume. All of the Trichoptera observed in August were hydroptilid larvae. *Oxyethira* (RI = 5) comprised approximately 15% of the hydroptilid larvae observed in intestines during August, contributing 6 percent to the total intestinal volume. Other hydroptilid larvae (RI = 38) contributed 34 percent to the total intestinal volume (Table F-20). Trichoptera were of less importance in June and July, contributing 8 and 5 mean percent volume, respectively. Chironomids were highly selected for in June and August (E = 0.88 and E = 1.00, respectively) (Table F-21). In July, the Electivity Index indicates that chironomids were slightly selected against (E = -0.07), despite the fact that chironomid larvae were the most important food. The apparent discrepancy can be explained by the fact that $\overline{ri}$ is based upon mean numbers per intestine, and in July, the dace consumed many individuals of an unidentified first instar larvae (not chironomid), which strongly influenced the calculation of electivity.

The dace also fed on adult terrestrial insects found in the drift. This was especially evident in July, when terrestrial insects and spiders accounted for 33 percent of intestinal volume. Visual observations at Ash Spring also indicated that speckled dace often fed on drift organisms.

Very little plant material was observed in intestines of speckled dace. During June, Spirogyra was the only plant present in intestines, accounting for only 2 mean percent volume. Spirogyra and Compsopogon comprised 9 mean percent volume of intestines in July, when plant material comprised 12 mean percent volume of intestines, the highest value reported for any month. During August, plants accounted for only 4 mean percent volume of speckled dace intestinal contents.

The mean ratio of intestine length to standard length was less than one in all speckled dace examined, indicating carnivory (Odum, 1970). The peritoneum had a mottled black color. This color was not as intense as the black peritoneum of Crenichthys, Catostomus or Poecilia examined.

Gambusia affinis

The diet of mosquitofish, Gambusia affinis, is almost entirely composed of animal matter (97 mean percent volume) with small amounts of debris. Mosquitofish feed heavily upon moderately large adult insects (RI = 39) (Table F-22), which are probably found in the surface drift. Most organisms examined from the guts were highly masticated, which precluded a more detailed identification. Formicid and chironomid adults were also fed upon, further suggesting surface feeding by this species. Field observations indicate mosquitofish are surface-dwellers near the stream margins, and the dorsally oriented mouth again relates to a surface feeding strategy.

Substrate feeding, as evidenced by the rare occurrence of a snail, Melanoides tuberculatus, in the stomachs of mosquitofish, is minimal. It appears that negative selection for this snail is occurring in the habitat. A few other types of insect larvae were also consumed.

The mean ratio of intestine length to standard length for mosquitofish is 0.71. This value falls into Odums (1970) category of less than 1.0, which suggests carnivorous feeding.

Poecilia mexicana

In all months for which intestinal contents were examined, shortfin mollies were herbivorous. Observed foods included Spirogyra, Oedogonium, Compsopogon, Lyngbya, and an unidentified filamentous alga (Figures F-36 through 39). In June, July, and September, Spirogyra was the primary food, contributing 36, 27, and 20 mean percent volume, respectively (Table F-23, 24 and 26). Spirogyra contributed 15 mean percent volume in August, when it was the second most important food (RI = 44) (Table F-25). The mollies ingested primarily Oedogonium (RI = 48) in August, with this food contributing 26 mean percent volume. Oedogonium was utilized in September in small amounts (one mean percent volume). Compsopogon and an unidentified filamentous alga were also ingested during August in small amounts, both contributing less than one mean percent volume. In June, Compsopogon was also lightly utilized (one mean percent volume). During September, shortfin mollies consumed Lyngbya, and an unidentified filamentous alga, as well as the Spirogyra and Oedogonium mentioned above.

Detritus was a major component of intestinal contents in all samples, constituting 63 mean percent volume in June, 73 in July, 58 in August, and 77 in September. The detritus was probably accidentally ingested by shortfin mollies while they fed on algal mats covering bottom sediments.

All animal foods for which selectivity indices were calculated, showed that shortfin mollies selected against animal foods (Table F-21).

In all specimens examined, the mean ratio of intestine length to standard length exceeded three. This ratio indicates herbivory (Odum, 1970). These fish possess a black peritoneum, a characteristic associated with herbivory in some fishes (Smith, 1966).

Cichlasoma nigrofasciatum

In June, the cichlids were primarily carnivorous, with animal matter occurring in 90 percent of the intestines examined and contributing 68% volume. Chironomid larvae (RI = 27) were of primary importance, with a mean percent volume of 51% (Table F-27). Furthermore, selectivity indices given in Table F-21 suggest that chironomid larvae are highly selected for by cichlids (E = 0.87, L = 0.79). Hydroptilidae were also highly selected (E = 1.00, L = 0.13). This trichopteran comprised 8 mean percent volume.

Cichlids were predominately herbivorous in July. Plants occurred in all intestines examined, averaging 60% of intestinal volume. Spirogyra (RI = 27) occurred in 100% of the intestines examined, contributing 55% volume (Table F-28). Chironomid larvae were ingested by all fish examined and were the most important animal food (RI = 19) with an average of 17.8 larvae per intestine, contributing 11% volume. Indices of selectivity indicate that chironomids were selected for in July, but with less intensity than in June (E = 0.50, L = 0.44).

In August, the fish consumed primarily chironomid larvae (40 mean percent volume) and Trichoptera (21 mean percent volume) (Figure F-42). The relative importance of Oxyethira (RI = 15) indicates that it was a heavily utilized hydroptilid trichopteran (Table F-29). Both chironomids and hydroptilids were highly selected for in August (E = 1.00, L = 0.56 and E = 1.00, L = 0.39, respectively).

September data indicated that the cichlids fed about equally on animal matter, plant matter, and detritus (Figure F-43). Spirogyra and Trichoptera contributed the largest percent volumes, 23 and 18, respectively (Table F-30). Chironomid larvae were also important, contributing 9 percent volume. Cichlids, once again, selected for both chironomids and hydroptilids (E = 0.12, L = 0.08 and E = 0.71, L = 0.39, respectively).

In June and August, the only months for which abundance in the environment was determined, cichlids selected against Melanoides. This snail was the predominate item in samples of the habitat during June and August. For both months, the Electivity Index was -1.00. The Linear Index was -0.91 and -0.94 in June and August, respectively.

The mean ratio of intestine length to standard length for Cichlasoma nigrofasciatum was 1.2. This indicates a feeding habit, borderline between carnivory and omnivory (Odum, 1970). The fish examined had a black peritoneum, a condition indicative of herbivory in some fishes (Smith, 1966). Intestinal contents indicate that the cichlids in Ash Spring were variable in their food habits and usually were omnivorous.

IMPACTS AND MANAGEMENT NEEDS

Until specific construction sites are selected, specified actions proposed, and specific influences on aquatic habitats predicted, it will be impossible to assess direct impacts of proposed actions. Nevertheless, at this time, it is possible to discuss some probable impacts and make general recommendations for minimizing or avoiding adverse impacts on sensitive aquatic habitats within the proposed M X deployment area. Aquatic habitats in the area depend on uninterrupted groundwater flows rather than surface runoff. Therefore, pumping of groundwater in the aquifer supplying a spring, either upflow or downflow from the spring source, can reduce the flow of the spring and may adversely affect the biota of the spring and its outflow.

In central and southern Nevada several types of aquifers exist (Mifflin, 1968; Winograd and Thordarson, 1975). Some of these are intrabasin aquifers while others are interbasin aquifers. Indentification of the types and locations of these aquifers before the pumping of groundwater in the M X deployment area is of extreme importance. Winograd and Thordarson (1975) found interbasin transport via the lower carbonate aquifer through Yucca Flats, Frenchman Flats, Oasis Valley, Ash Meadows to Death Valley. This lower carbonate aquifer is at least 4,500 square miles in area and is located in a minimum of ten intermontane basins. Springs discharging from this system provide habitats for endemic fauna throughout portions of Nevada and California, including the M X deployment area. Management of these aquifers is of great importance in providing for continued existence of these springs.

Permits in Nevada may be issued to allow pumping of groundwater, even if reduction or cessation of spring flow is a likely consequence of such pumping. This is true because some lowering of the water table is considered to be a normal and even sometimes a desirable consequence of utilization of groundwater resources. Pumping is not normally permitted in excess of annual recharge, but good water management may involve some lowering of the water table and drying up of springs as a means of lowering the amount of evapotranspiration. To avoid the adverse impact that would result from reduction or cessation of spring flows it is necessary to refrain from utilization of ground water resources in a way that would affect spring flows.

Construction activities, can also directly alter spring sources and their outflows. Avoidance of adverse impacts resulting from construction activities requires that these activities be kept away from aquatic habitats. Such things as filling tank trucks from natural open water areas, locations of temporary construction camps near spring sources, alteration of outflow channels, and similar activities can have profound and lasting adverse effects on natural aquatic habitats.

Our studies to date have demonstrated that indirect impacts of M X construction on aquatic habitats in Nevada are likely to be considerably more profound and permanent than are the primary impacts of construction. This, of course, assumes that construction will deliberately avoid irreparable damage. Deacon et al. (1964), Hubbs and Deacon (1964) and Deacon (1979) have demonstrated that people tend to move aquarium fish into Nevada springs to the marked detriment of the native fauna. This problem is certain to be compounded as public use of aquatic habitats increases.

This study has shown that the introduced Oriental snail, Melanoides tuberculatus, occurs in the outflow of Ash Spring in great abundance. This Oriental snail, as is true of the exotic fishes, was apparently introduced by an aquarist. Melanoides tuberculatus affects native aquatic organisms, either by its opportunistic feeding behavior or by its physical disturbance of substrates, including dislodging eggs. The magnitude and mechanics of these effects are not well known or documented. In the outflow of Ash Spring, other species of native snails formerly occurring there have been eliminated, and other macroinvertebrates have probably been severely reduced by this introduced aquarium snail. This Oriental snail also has a very thick shell and grows to a relatively large size, which results in its lack of value as a fish food organism. The consequence appears to be that M. tuberculatus significantly reduces availability of fish food organisms in environments occupied by it. This results in significant reductions in fish populations dependent on organisms replaced by M. tuberculatus. The problem is certain to be compounded by the inevitable increase in public use of these aquatic habitats that will accompany M X construction and operation.

Partial mitigation of problems associated with introduction of exotic species is probably possible only by the establishment of ecological preserves encompassing large representative habitats. These preserves would require limited public access and continuous management in order to successfully accomplish the purpose of maintaining the natural integrity of representative desert aquatic environments. Additional mitigation to reduce the impact of increased population includes a continuing public education program, a conservation education program in the public schools, U.S.A.F. personnel orientation programs, and general meetings in the M X missile impact area. These measures, of course, can only be expected to somewhat reduce the adverse impacts.

At Preston Big Spring, we have determined that the White River spinedace, formerly a common species at this location, has disappeared from the fauna. The species still occurs in other waters in White River Valley. In addition, the White River desert sucker is apparently much less common than formerly expected. This appears to have resulted from an irrigation and domestic water project which left the spring source and about a mile of the outflow unaltered before funneling all of the water into an underground pipe for distribution. We suspect that isolating the spinedace and desert sucker subpopulations from their normal communications with other subpopulations in the drainage led to some kind of interruption of the normal life cycle patterns which resulted in extirpation of the Preston Big Spring population of White River spinedace and severe reduction of the Preston Big Spring population of the White

River desert sucker. This experience indicates that manipulation of spring flows, even when substantial segments are left undisturbed, can have very significant adverse consequences for the species occuring in the protected area. Therefore, it is clear that if mitigation of adverse impacts and creation of ecological preserves are contemplated, the size of the preserve and opportunities for communication of the populations in the proposed preserve as well as the detailed life history of the species of concern must be given very careful consideration. White (1979), in discussing strategies for the preservation of rare animals, clearly demonstrates the advantages of large continuous habitats over smaller discontinuous habitats. The loss of the White River spinedace from Preston Big Spring illustrates the significance of this principle for maintenance of viable populations in desert aquatic habitats in Nevada.

Frequently, it is suggested that transplanting an endangered or rare species into another habitat removed from the area of impact is a viable method of mitigating an adverse impact. In fact, it appears at first that this strategy, employed at Shoshone Ponds where the Pahrump killifish exists, has succeeded. In reality, it has not. Success of this strategy will come only if the population being temporarily maintained in Shoshone North Pond can be used to reestablish the species within its original range. We specifically recommend that transplanting not be considered a viable mitigation strategy. A species exists as a functioning part of an ecosystem. Removing it from the ecosystem within which it evolved subjects the species to a new set of selective pressures. For transplanted species, these selective pressures, while not fully understood by man, are nevertheless chosen by man. The outcome, therefore, is not to save the species, but rather to alter it in incompletely understood ways. The species is an integral part of the ecosystem in which it exists. Thus, mitigation measures can only be considered successful insofar as they permit a species to continue its existence in its natural habitat. Transplanting is a technique to be used as a temporary means of maintaining a population or a species until it can be returned to its natural habitat.

In summary, we recommend that direct adverse impacts of the M X missile system on aquatic habitats in Nevada be avoided by selecting areas where pumping of groundwater and construction activities will not influence important aquatic habitats. Secondary impacts, such as exotic species introduction, cannot be avoided and will be severe. Some mitigation is possible by public education programs and by establishing a series of relatively large refuge areas representative of desert aquatic habitats in Nevada.

RESEARCH DIRECTIONS

In order to develop an approximate understanding of any ecosystem, information must be obtained at intervals throughout an entire year. A detailed and reasonably reliable understanding requires several years of investigation involving continuous refinement of the investigation. In general, we believe the level of understanding necessary to do a reasonably valid assessment of environmental consequences of MX missile construction and deployment requires at least one additional year of less frequent data collection at more locations. This effort must then be followed by site-specific investigations as specific deployment locations are identified.

Preston Big Spring contains a diverse native fish fauna as well as a diverse invertebrate fauna. Both show important changes seasonally. We recommend continuing an intensive effort toward understanding ecosystem dynamics at Preston Big Spring. Essentially, the data collection scheme currently in use should be retained but collection frequency should be bimonthly rather than monthly.

At Lockes Ranch, few changes are evident in biological populations living in the main study area. Considerable diversity and seasonal variability is evident, however, in lateral or downstream areas, especially where Utricularia is dominant. These areas also are heavily utilized as spawning beds by Railroad Valley springfish. Bimonthly sampling of invertebrate populations in these Utricularia beds is recommended. The full sampling program at Lockes Ranch Spring should be done quarterly.

Shoshone Ponds show marked seasonal changes in the invertebrate populations. The fish, on the other hand, probably fluctuate more slowly. We suggest that invertebrates be sampled bimonthly but that fish should be followed only quarterly. Sampling should include all three ponds. Here the data will be especially useful in determining the differences between invertebrate populations in temporary or artificial habitats with and without fish predators.

At Burns Ranch, in the outflow from Ash Spring, the invertebrate populations are dominated by Melanoides, diversity is low and seasonal changes are minimal. The fish population, however, undergoes significant seasonal changes. We, therefore, recommend quarterly sampling of the invertebrate population but bimonthly sampling of the fish population.

The changes in sampling recommended above should permit consideration of increasing the number of habitats from which biological data can be developed. We recommend the addition of four localities from which biological data is taken quarterly. In addition, survey work to determine the status of molluscan and fish populations throughout the deployment area should be undertaken. It appears that molluscan surveys are especially important for Steptoe, Snake and Monitor Valleys. Status of fish populations in many waters within the deployment area is relatively well known, however, many specific localities have either never been sampled or have not been sampled for several decades.

We believe the present, modified data collection system is appropriate with minor further modifications. Determination of density and distribution of fish eggs in all habitats could add extremely useful data on spawning habitats. These data also may be usefully adapted to our efforts at analyzing weighted usable area at different flow regimes. Therefore, we recommend addition of an examination of the distribution and density of fish eggs during January through September in each habitat.

Due to the nitrate situation at Lockes Ranch Spring and Preston Big Spring, further investigations should include a more extensive nitrate sampling program. This will aid in understanding the variability of the initial nitrate results.

At this point we have good information for four habitats during summer, 1980. In order to understand seasonal changes, it is especially important to continue the sampling program through the winter and spring. Additional sampling in summer 1981 would provide some idea of annual variations that can be expected in the habitats sampled.

In summary, we recommend continuing the sampling program to provide information from several habitats throughout the course of a year, allowing some time overlap in the sampling to provide some insight into annual as well as seasonal variation. Special effort at some locations can and should be directed toward identifying spawning habitat. Surveys of the status of molluscan and fish populations must be done. Additional information on concentration and variability of nitrate at Lockes Ranch Spring and Preston Big Spring should be developed.

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APPENDIX A

SPECIFIC AQUATIC SYSTEMS CONTAINING ENDEMIC FAUNA IN EAST-CENTRAL NEVADA

Endemic fish and mollusks constitute a majority of the unique aquatic fauna in east-central Nevada. Most of the endemic fish populations have been ascertained through the work of J. E. Deacon, T. Hardy, C. Hubbs, I. La Rivers, and R. R. Miller, but molluscan and other invertebrate inventories are not complete. A list of known specific aquatic ecosystems within the study basins is presented in Table A-1. Fish (F), limited molluscan (M), and other invertebrate (I) data are presented. These ecosystems should be avoided both directly and indirectly during MX construction and deployment. Additional fish information from other basins can be obtained from Hubbs et al. (1974), La Rivers (1962), Hardy (1980a), and Deacon (1979). All available freshwater molluscan information is presented from adjacent basins.

Table A-1. List of Sensitive Aquatic Ecosystems in East-Central Nevada

White River Valley				
Preston Big Spring	T12N-R61E-S2	F	M	
Cold Spring	T12N-R61E-S12	F	M	?
Nicholas Spring	T12N-R61E-S12	F	M	?
Arnoldson Spring	T12N-R61E-S2	F	M	?
Preston Town Spring	T12N-R61E-S12	F	M	
Indian Spring	T12N-R61E-S2	F	M	?
Lund Town Spring	T11N-R61E-S34	F	M	
Unnamed Spring	T11N-R62E-S21		M	
Moorman [Mormon] Spring	T9N-R61E-S32	F	M	
Hardy Springs	T9N-R61E-S13	F		M
Emmigrant Springs	T9N-R62E-S19	F		M
Flag Springs	T7N-R62E-S33	F	M	
Butterfield Springs	T7N-R62E-S28	F	M	
Hot Creek Spring	T6N-R61E-S18	F	M	
Moon Ranch Spring	T6N-R60E-S25	F	M	?
Railroad Valley				
Lockes Big Spring	T8N-R55E-S15	F	M	I
Chiminey Spring	T7N-R55E-S16*	F		
Corral Spring	T7N-R55E-S15	F	M	
North Spring	T7N-R55E-S16	F	M	
Reynolds 1, 2 Springs	T7N-R55E-S15	F	M	
Unnamed Spring	T8N-R57E-S1		M	
Butterfield Spring	T8N-R57E-S27	F	M	
Blue Eagle Spring	T8N-R57E-S11	F		
Bull Creek Springs	T14N-R57E	F	M	?
Little Warm Spring	T12N-R56E-S5	F	M	
Big Warm Spring	T13N-R56E-S32	F	M	
Duckwater Springs	T12N-R56E-S5	F	M	
Currant Springs	T11N-R57E-S1		M	
Spring Valley				
Shoshone Ponds	T12N-R65E-S2*	F		
Swallow (Shoshone) Ranch Springs	T12N-R65E-S36	M		
Grey Spring	T16N-R67E-S32	M		
Unnamed Spring	T16N-R67E-S32	M		
Unnamed Spring	T16N-R67E-S20	M		
Keegan Ranch Springs	T18N-R66E-S12	F		
Spring Valley Creek	T23N-R66E-S31	F		
Stone House Springs	T22N-R66E-S17	F		

(continued)

Table A-1. (continued)

Pahranagat Valley		
Ash Spring	T6S-R60E-S1	F M I
Crystal Springs	T5S-R60E-S10	F M
Hiko Spring	T4S-R60E-S14	M
Unnamed Spring	T8S-R62E-S32*	F
Steptoe Valley		
Upper Schellbourne Springs	T22N-R65E-S5	M
Cardano Ranch Springs	T25N-R64E-S5	F
Steptoe Ranch Springs	T19N-R63E-S5	F M
Grass Springs	T19N-R63E-S20	F M
Dairy Ranch Spring	T18N-R64E-S20	F
Ruth Pond	T16N-R62E-S3	F

*Introduced native fauna

Other basins in east-central Nevada are known to have unique aquatic species, mainly fish and mollusks. Unlike fish, the mollusks are unknown and/or unpublished. Other unique molluscan occurences include the following:

Kershaw-Ryan State Recreation Springs (T4S-R67E-S19)
Panaca Big Spring (T2S-R68E-S4)
Ruby and Butte Valleys
Moapa (Muddy) River Valley (Landye, 1973)

APPENDIX B

HABITAT MORPHOMETRY OF SELECTED SPRING HABITATS IN EAST-CENTRAL NEVADA

Tables are provided for each spring system indicating the species composition of the aquatic macrophyte and riparian zones. Maps and photos are also provided that delineate the habitat structure and distribution of the respective vegetation zones. Cross-sections of the habitats are given to show channel development.

Table B-1. List of plants. Identified from samples collected at all springs - June thru September, 1980. P = Preston Big Spring, L = Lockes Ranch Spring, S = Shoshone North Pond, A = Outflow of Ash Spring

Species Name	Common Name	Occurrence At Springs
Apiaceae		
Hydrocotyle sp.	Water-pennywort	A
Asclepiadaceae		
Asclepias speciosa Torr.	Milkweed	P
Asteraceae		
Artemisia tridentata	Big Sagebrush	P
Cirsium mohavense (Greene) Petrak	Thistle	L,P
Grindelia squarrosa (Pursh.) Dunal	Gum-plant	L
Solidago confinus Gray	Goldenrod	L
Sonchus asper (L.) Hill.	Sowthistle	L
Brassicaceae		
Rorippa nasturtium-aquaticum (L.) Schinz. & Thell.	Water-cress	P
Chenopodiaceae		
Nitrophila occidentalis (Nutt.) Moq.		A
Cyperaceae		
Carex sp.	Sedge	S
Eleocharis parishii Britton	Spikerush	S,L,P,A
Fimbristylis		L
Scirpus americanus Pers.	Olney Threesquare	S,L,P
Gentianaceae		
Centarium exaltatum (Griseb.) W. Wright	Great Basin Centaury	L
Juncaceae		
Juncus sp.	Rush	S,L,P
Lamiaceae		
Mentha arvensis L.	Mint	P
Najadaceae		
Naja marina L.	Naiad	A
Oleaceae		
Fraxinus velutina Torr. var. *coriacea* (Wats.) Rydb.	Ash	A
Onagraceae		
Epilobium ciliatum Raf.	Willow-herb	P

(continued)

Table B-1. (continued)

Species Name	Common Name	Occurrence At Springs
Plantaginaceae		
Plantago major L.	Common Plantain	P
Poaceae		
Distichlis spicata (L.) Greene	Salt Grass	A,S
Polypogon monspeliensis (L.) Desf.	Rabbitfoot Grass	P
Rosaceae		
Potentilla anserina L.	Cinquefoil	S,P
Salicaceae		
Salix sp.	Willow	A,P
Saxifragaceae		
Ribes sp.	Current	P
Sauraceae		
Anemopsis californica (Nutt.) Hook. & Arn.	Yerba Mansa	L,A
Schrophulariaceae		
Castillaja sp.	Paintbrush	L
Mimulus guttatus Fisch. ex DC.	Monkey Flower	P,S
Penstemon palmeri Gray	Palmer's Penstemon	P
Veronic anagallis-aquatic L.	Speedwell	P,S
Vitaceae		
Vitis california Benth.	California Grape	A
Lentibulariaceae		
Utricularia vulgaris L.	Bladderwort	L

Table B-2. Estimated Percent Cover of Plant Species at Preston Big Spring, July, 1980.
Misc. = Miscellaneous   Ast = Asteraceae   Scr - *Scirpus*   Cr = Cress   Jun = *Juncus*

	EAST				WEST			
TRANSECT NO.	RIPARIAN VEGETATION	%	AQUATIC VEGETATION	%	RIPARIAN VEGETATION	%	AQUATIC VEGETATION	%
100-95	*Juncus*	85	Cr	90	---		Scr	95
	Thistle	10	Scr	5	---		Cr	5
	Misc.	5	Misc.	5	---			
95-90	*Juncus*	50	Cr	100	*Juncus*	60	Scr	95
	Sage Brush	25			Thistle	20	Cr	5
	Misc.	25			*Salix*	20		
90-85	Misc.	75	Cr	100	*Salix*	95	Scr	50
	Juncus	10			*Juncus*	5	Cr	50
	Sage Brush	15						
85-80	*Juncus*	55	Jun	15	*Salix*	100	Scr	50
	Sage Brush	20	Cr	80			Cr	50
	Thistle	25	Misc.	5				
	Rabbit Brush	40	Scr	50	*Salix*	100	Scr	50
	Juncus	40	Cr	50			Cr	50
	Thistle	15						
	Misc.	5						
75-70	Sage Brush	40	Scr	60	*Salix*	100	Scr	95
	Misc.	20	Cr	40			Cr	5
	Juncus	40	Cr	80				
70-65a	*Salix*	100	Scr	20				
65a-65b	Misc.	90	Scr	90	*Salix*	100	Cr	90
	Juncus	10	Cr	10			Scr	10

(continued)

Table B-2. (continued)

TRANSECT NO.	EAST RIPARIAN VEGETATION	%	EAST AQUATIC VEGETATION	%	WEST RIPARIAN VEGETATION	%	WEST AQUATIC VEGETATION	%
65b-60	_Juncus_	75	Scr	80	_Salix_	80	Scr	75
	Misc.	25	Cr	15	Rose	20	Cr	25
			Misc.	5				
60-55	Misc.	50	Scr	20	_Salix_	95	Scr	85
	Juncus	50	Cr	80	Rose	5	Cr	5
55-50	Rose	10	Cr	5	_Salix_	100	Scr	90
	Sage Brush	20	Scr	85			Cr	10
	Alfalfa	35	Misc.	15				
	Misc.	35						
50-45	Rose	90	Scr	95	_Salix_	100	Scr	95
	Misc.	10	Cr	5			Cr	5
45-40	Rose	95	Scr	95	_Salix_	100	Cr	90
	Misc.	5	Cr	5			Scr	10
40-35	Rose	85	Scr	33	_Salix_	100	Scr	90
	Misc.	15	Cr	33			Cr	5
	Juncus	5	Algae	33			Algae	5
35-30	Current	95	Scr	80	_Salix_	50	Scr	50
	Misc.	5	Algae	10	Rose	50	Cr	25
			Cr	10			Algae	25
30-25	Current	95	Scr	33	Rose	98	Scr	80
	Misc.	5	Cr	33	_Salix_	2	Cr	15
			Algae	33			Algae	5

(continued)

Table B-2. (continued)

TRANSECT NO.	EAST RIPARIAN VEGETATION	%	AQUATIC VEGETATION	%	WEST RIPARIAN VEGETATION	%	AQUATIC VEGETATION	%
25-20	Current	95	Scr	80	Rose	50	Scr	90
	Misc.	5	Cr	10	Ast.	45	Cr	5
			Algae	10	Salix	5	Algae	5
20-15	Rose	20	Scr	90				
	Sage Brush	20	Cr	10	Misc.	50	Scr	50
	Misc.	50			Ast.	50	Cr	40
	Juncus	10					Algae	10
15-10	Current	80	Scr	50	Ast.	90	Cr	90
	Juncus	15	Cr	50	Misc.	10	Scr	10
	Misc.	5						
15-05	Soil	95	Scr	5	Misc.	100	Scr	90
	Misc.	5	Cr	95			Cr	10
05-00	Dirt	100	Scr	98	Dirt	100	Scr	98
			Misc.	2			Misc.	2

Table B-3. Substrate, Depth, and Current Profiles for Transect Data Collected at Preston Big Spring, Nevada - June, 1980.
S = Substrate D = Depth C = Current

TRANSECT NO.	EAST EDGE			MIDDLE			WEST EDGE		
	S	D*	C**	S	D*	C**	S	D*	C**
0	Soil	---	---	Soil	---	---	Soil	---	---
5	Mud	---	---	Mud	---	---	Mud	---	---
10	"	.52	0	"	.49	0	"	.34	0
15	"	.37	.03	"	.37	.06	"	.37	.09
20	"	.30	0	"	.37	.09	"	.27	.03
25	Sand	.27	.2	Sand	.43	.2	Sand-Mud	.37	.2
30	Sand-Mud	.34	.03	"	.43	.18	"	.43	.06
35	Sand	.33	.03	"	.40	.24	Sand	.40	.03
40	Mud	.37	.09	"	.43	.18	Sand-Mud	.43	.03
45	Sand-Mud	.33	.06	Sand-Gravel	.37	.27	"	.37	.06
50	Sand	.30	.03	Sand	.30	.40	Sand	.37	.06
55	Sand-Mud	.27	.21	Sand-Gravel	.34	.43	Sand-Mud	.30	.06
60	"	.37	.15	"	.40	.58	Sand-Gravel	.34	.15
65a	"	.37	.15	"	.46	.58	Sand	.37	.03
65b	Mud-Gravel	.34	.15	"	.37	.85	Sand-Gravel	.37	.06
70	"	.27	.06	Gravel	.43	.55	Mud-Gravel	.40	.06
75	"	.34	.06	"	.40	.73	Sand-Gravel	.40	.34
80	"	.37	.27	Sand-Gravel	.46	.73	"	.40	.18
85	"	.37	.18	"	.43	.61	"	.43	.27
90	"	.40	.12	"	.43	.76	Mud-Gravel	.40	.37
95	Gravel	.37	.34	Gravel	.40	.76	"	.30	.30
100	Gravel-Rock	.43	.18	"	.43	.85	"	.40	.21

* Depth is in meters
** Current is in meters per second

Table B-4. Substrate, Depth, and Current Profiles for Transect Data Collected at Lockes Ranch Spring, Nevada - June, 1980.
S = Substrate D = Depth C = Current Trav = Travertine

TRANSECT NO.	EAST EDGE			MIDDLE			WEST EDGE		
	S	D*	C**	S	D*	C**	S	D*	C**
0	Soil-Mud	---	---	Soil-Mud	---	---	Soil-Mud	---	---
5	"	.61	---	Mud	.70	---	"	.49	---
10	Mud	.37	---	"	.73	.03	Soil	.27	---
15	Soil-Mud	.30	.03	"	.40	.09	"	.30	.03
20	Soil	.30	.12	"	.34	.15	"	.37	.03
25	"	.30	.06	Trav Sand-Mud	.40	.15	Trav Sand	.34	.03
30	"	.18	.03	Trav Sand	.27	.27	"	.24	.09
35	Trav Sand	.21	.03	"	.27	.21	"	.27	.09
40	"	.15	.12	"	.27	.24	"	.21	.06
45	Soil	.21	.12	"	.24	.27	"	.18	.06
50	Trav Sand-Soil	.21	.03	"	.24	.30	Trav Sand-Soil	.15	.15
55	Soil	.18	.03	Trav Pebbles	.21	.24	Soil	.21	.09
60	Trav Sand	.15	.15	Trav Sand	.34	.15	"	.06	.03
65	"	.18	.03	"	.21	.21	"	.15	.12
70	"	.18	.03	Trav Pebbles	.21	.27	"	.18	.24
75	"	.21	.03	"	.21	.27	Trav Sand	.21	.09
80	"	.18	.03	Trav SAnd	.21	.06	"	.21	.03
85	Soil-Mud	.15	.06	"	.15	.12	Soil-Mud	.15	.03
90	Trav Sand	.12	.03	Trav Pebbles	.18	.09	Soil	.18	.03
95	Mud	.21	.12	Trav Sand-Pebbles	.27	.21	Trav Sand	.15	---
100	Trav Sand	.21	.03	"	.21	.09	"	.18	---

* Depth is in meters
** Current is in meters per second

Table B-5. Substrate and Depth Profiles for Transect Data Collected at Shoshone North Pond, Nevada - June, 1980.

TRANSECT NO.	SUBSTRATE	DEPTH*
1,10	Mud-Gravel	.24
2,10	"	.46
3,10	"	.43
4,10	"	.34
5,10	"	.21
16	"	.37
17	"	.40
18	"	.37
19	"	.40
26	"	.43
27	"	.98
28	"	.61
29	"	.91
36	"	.43
37	"	1.07
38	"	1.34
39	"	1.19
46	"	.43
47	"	.98
48	"	.93
49	"	.85
56	"	.27
57	"	.40
58	"	.94
59	"	.67

* Depth is in Meters

Table B-6. Substrate, Depth, and Current Profile for Transect Data Collected at Ash Spring, Nevada - June, 1980.
S = Substrate D = Depth C = Current

TRANSECT	EAST EDGE			MIDDLE			WEST EDGE		
NO.	S	D*	C**	S	D*	C**	S	D*	C**
0	Mud	.09	.03	Sand-silt	.34	.18	Mud	.49	.03
5	"	.30	---	"	.55	.24	"	.49	.27
10	"	.09	---	"	.61	.24	"	.64	.15
15	"	.09	---	Sand	.73	.21	Sand	.73	.18
20	"	.24	---	"	.67	.34	Mud	.73	.15
25	"	.21	---	Mud	1.07	.37	Sand	1.07	.03
30	"	.30	---	Sand	.46	.24	Mud	.21	.03
35	"	.21	.06	Sand-silt	.43	.21	"	.43	---
40	"	.30	.09	"	.37	.21	"	.15	---
45	"	.12	.03	Mud	1.04	.15	"	.12	---
50	"	.09	---	Sand	.85	.15	"	.79	.18
55	"	.09	---	"	.61	.21	"	.61	.15
60	"	.12	---	Sand-silt	.70	.24	Sand-silt	.82	.15
65	"	.18	.12	Silt	.67	.27	"	.76	.06
70	"	---	---	Silt-sand	.67	.34	"	.70	.09
75	"	.15	---	Sand	.58	.30	Mud	.40	.09
80	"	.27	---	"	.61	.34	"	.34	.09
85	"	.30	---	Silt-sand	.61	.34	"	.52	.09
90	"	.12	---	"	.58	.33	"	.63	.15
95	"	.18	.03	"	.58	.30	"	.55	.12
100	"	.27	---	"	.52	.24	"	.30	.03

* Depth is in meters
** Current is in meters per second

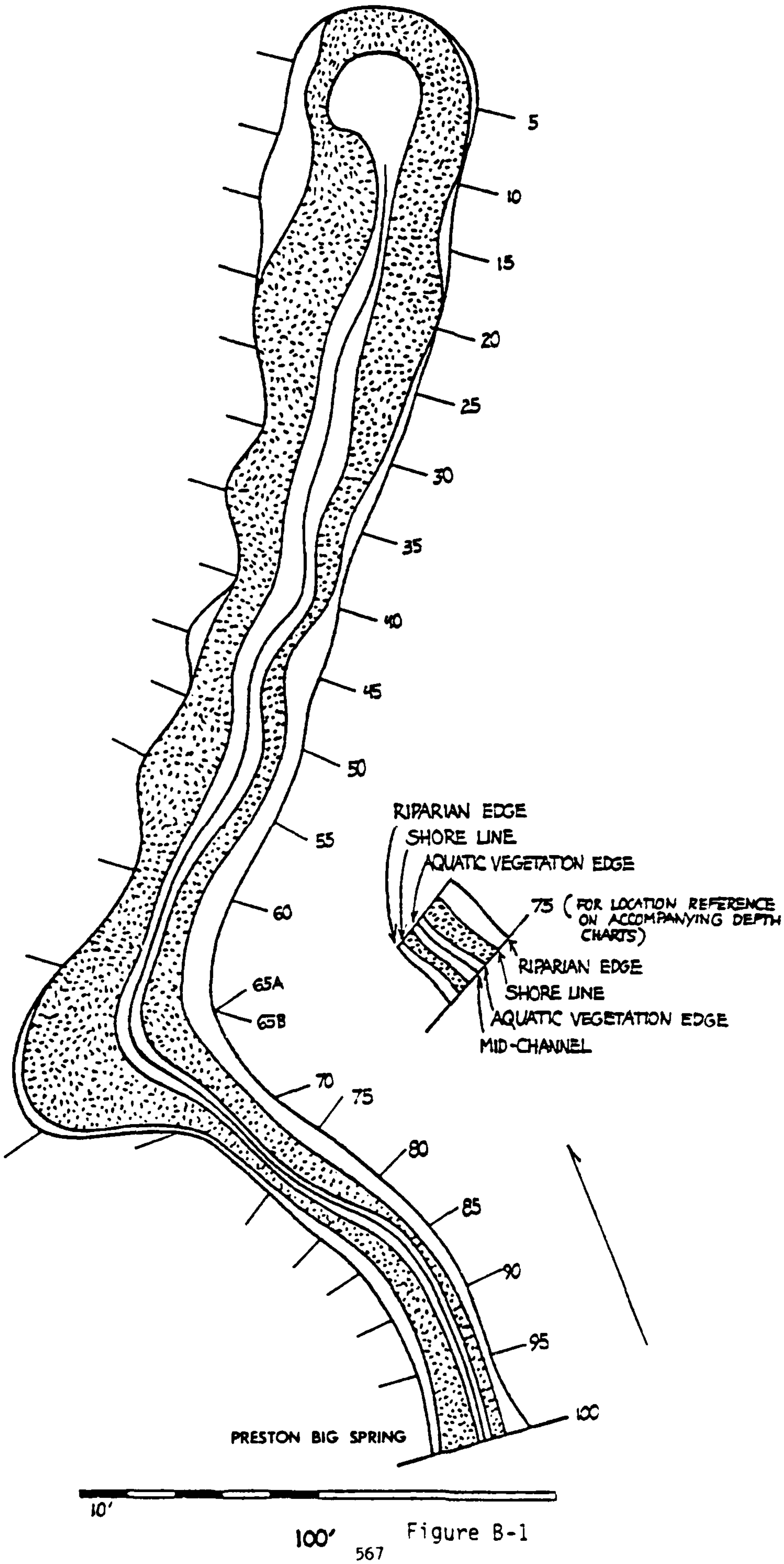

5
10
15
20
25
30
35
40
45
50
55
60
65A
65B
70
75
80
85
90
95
100
RIPARIAN EDGE
SHORE LINE
AQUATIC VEGETATION EDGE
75 (FOR LOCATION REFERENCE ON ACCOMPANYING DEPTH CHARTS)
RIPARIAN EDGE
SHORE LINE
AQUATIC VEGETATION EDGE
MID-CHANNEL
PRESTON BIG SPRING
10'
100'

Figure B-1

Figure 8-2. Channel development at Preston Big Spring.

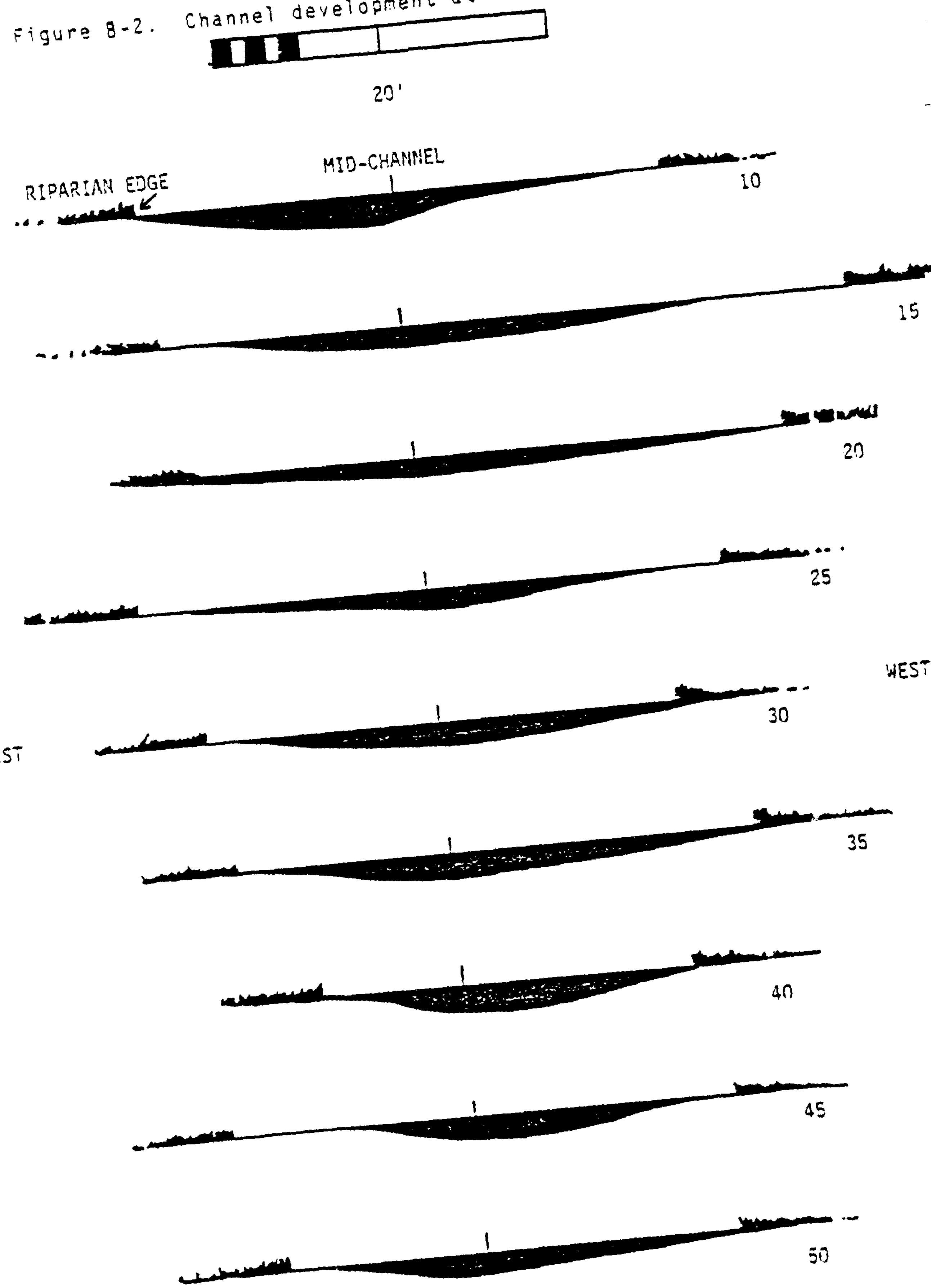


Figure B-3. Channel development at Preston Big Spring.

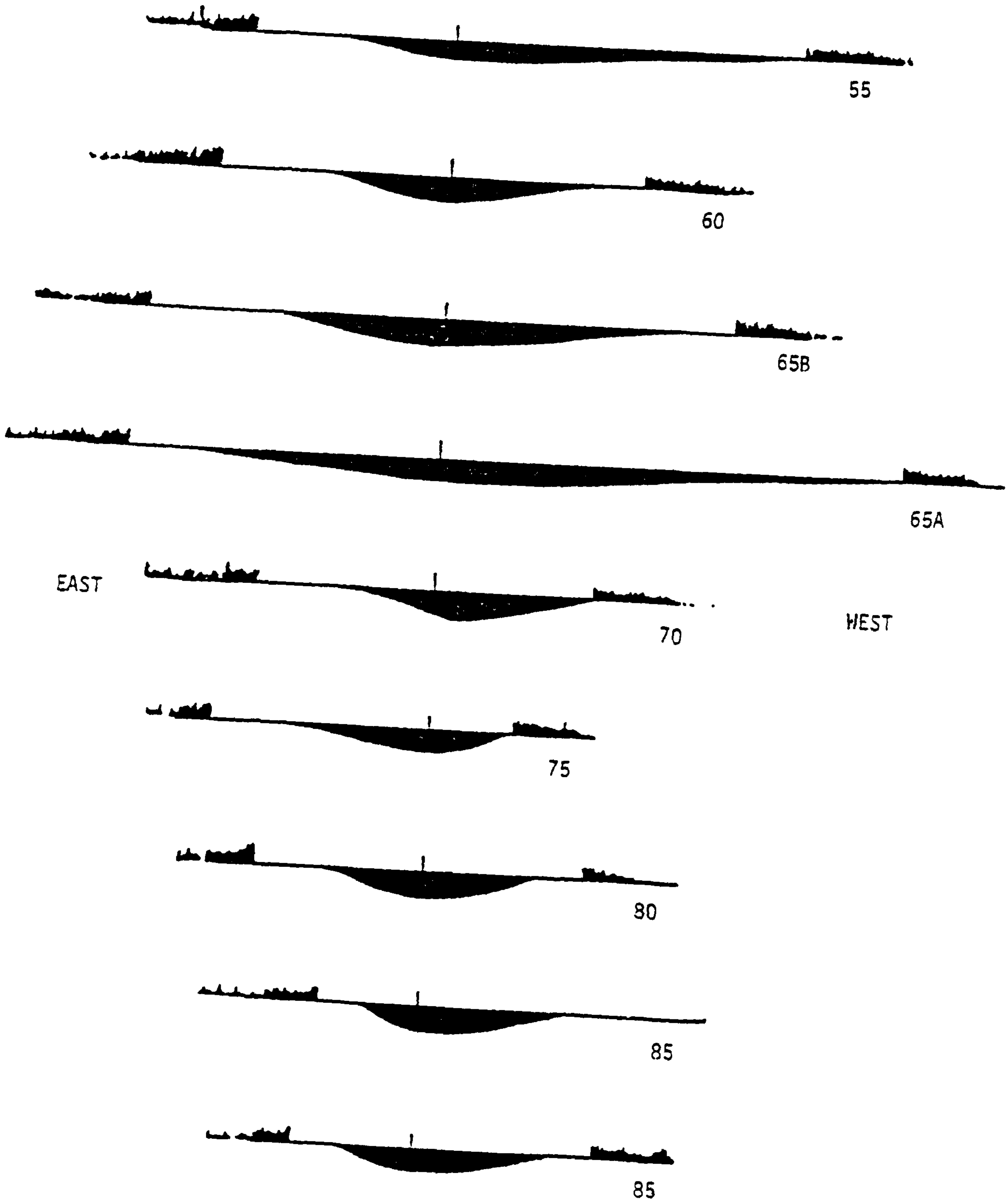
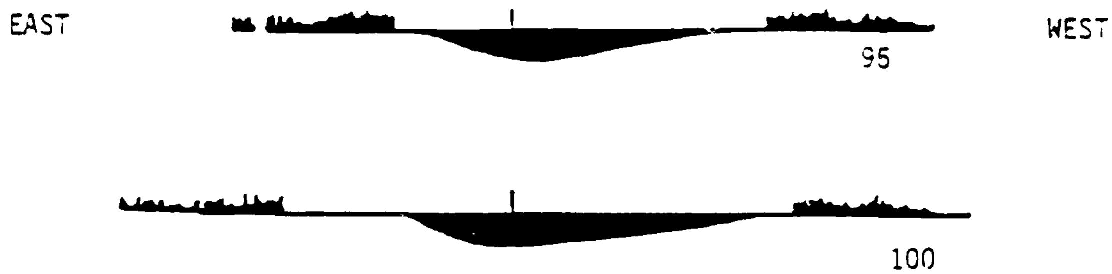
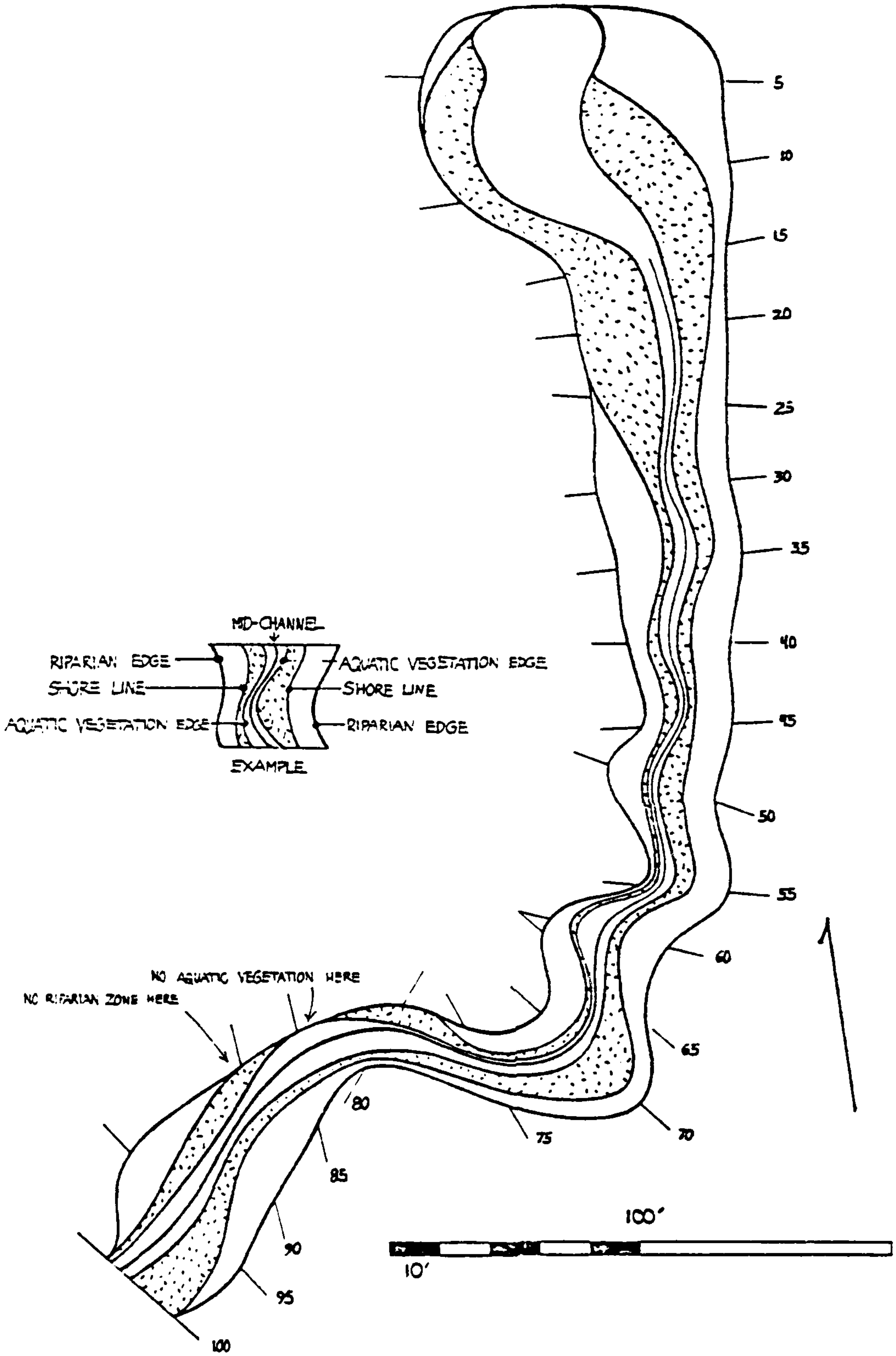


Figure B-4. Channel development at Preston Big Spring.





LOCKES RANCH

Figure B-5

Figure B-6. Channel development at Lockes Ranch.

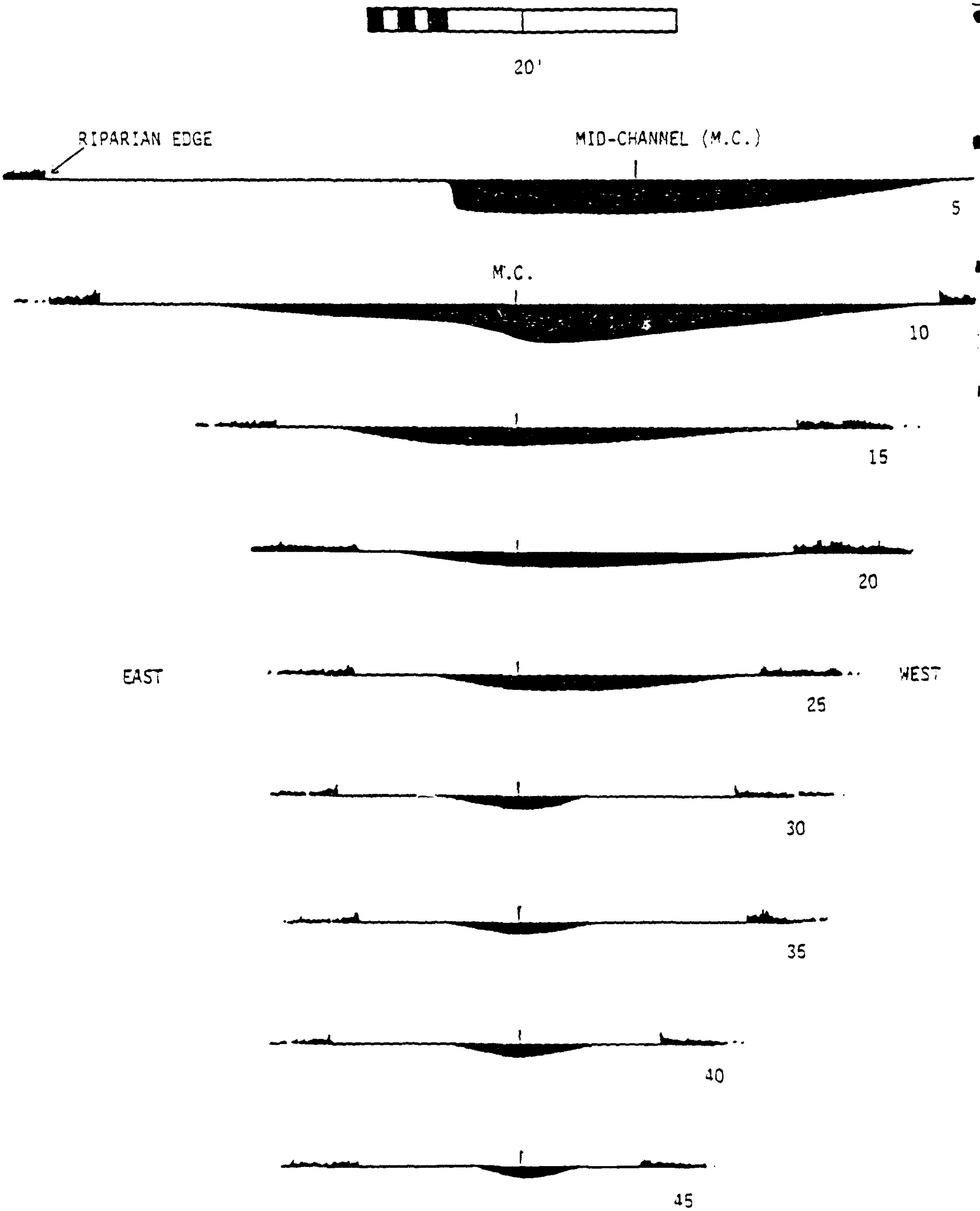
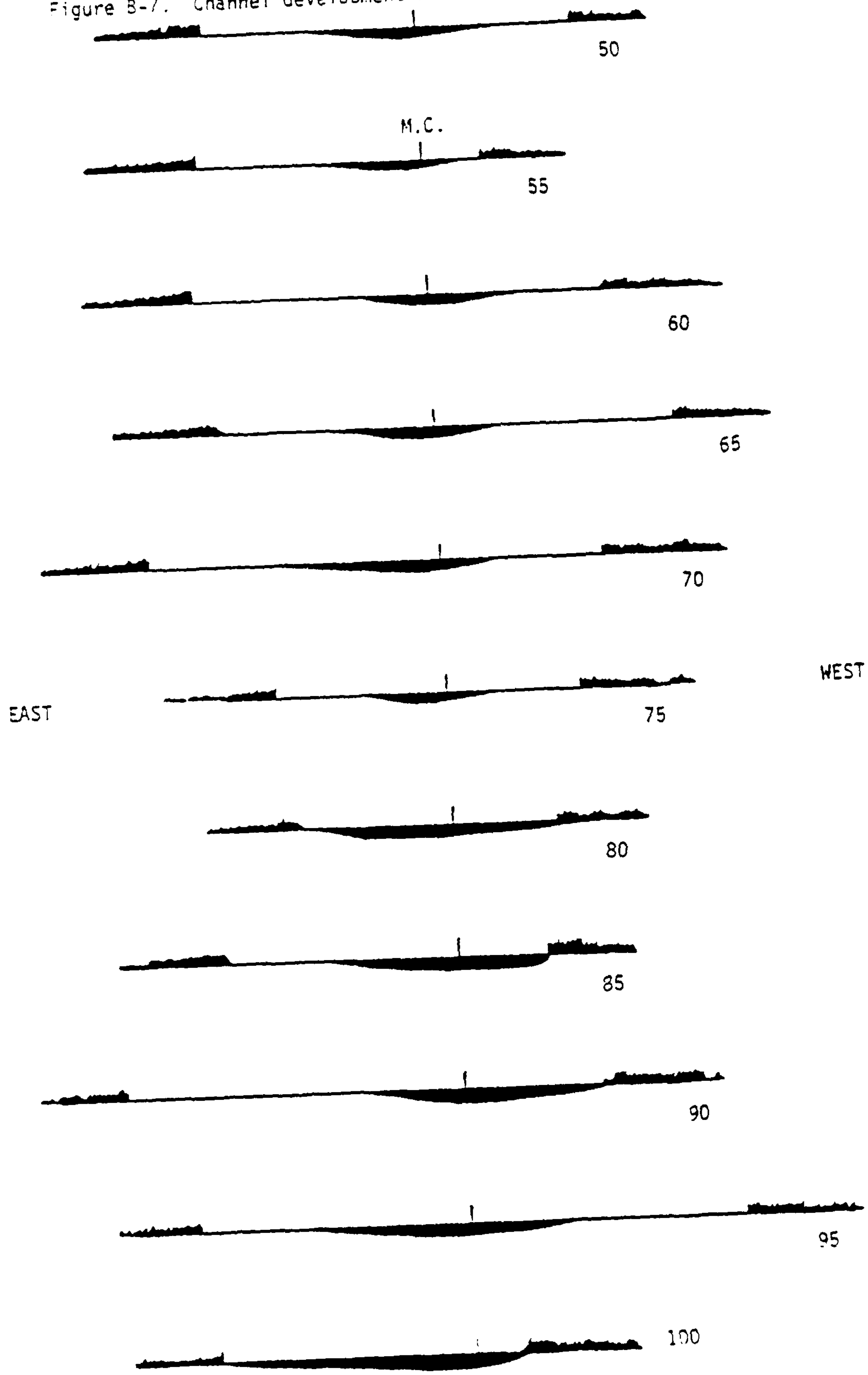


Figure B-7. Channel development at Lockes Ranch.



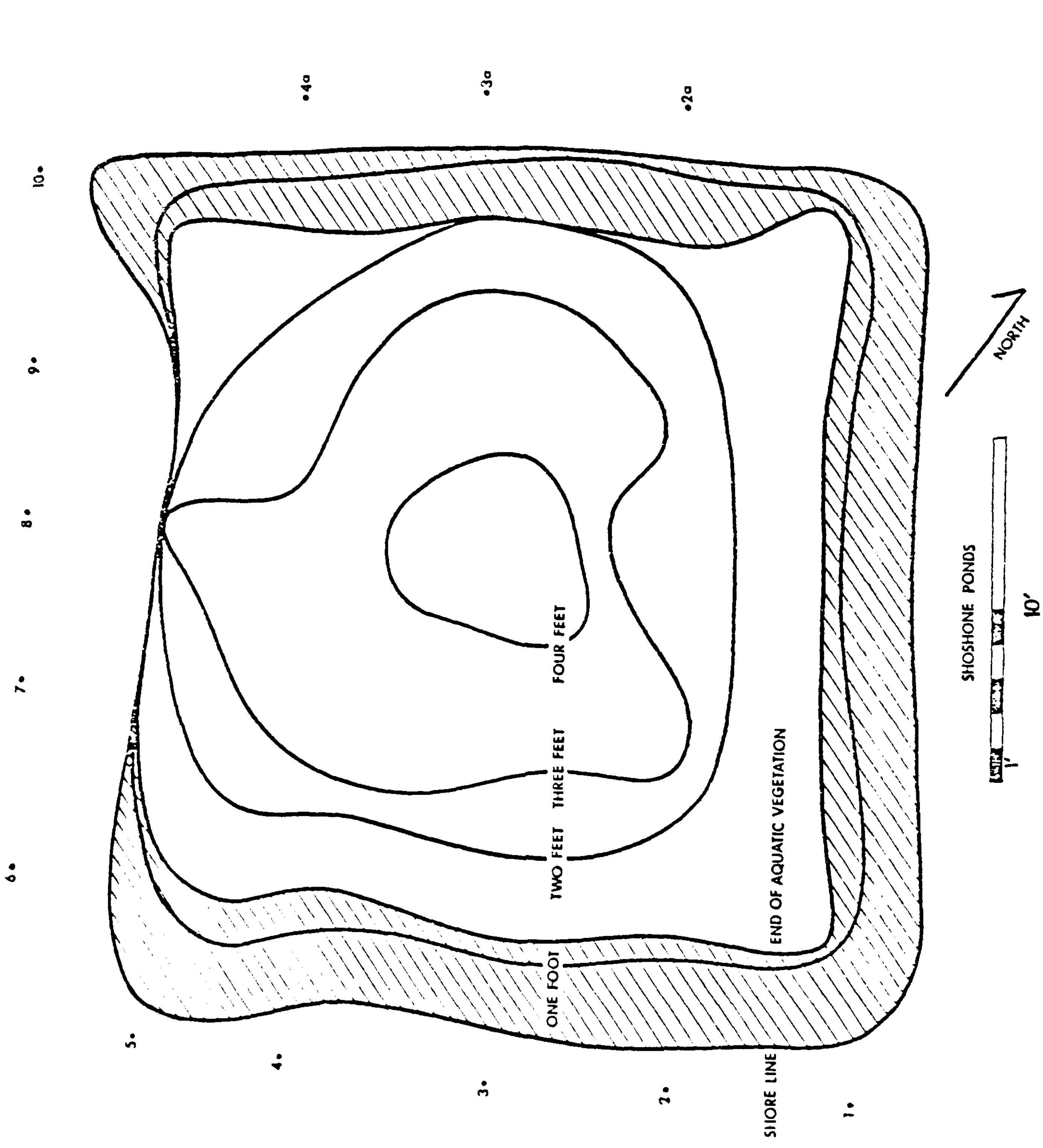
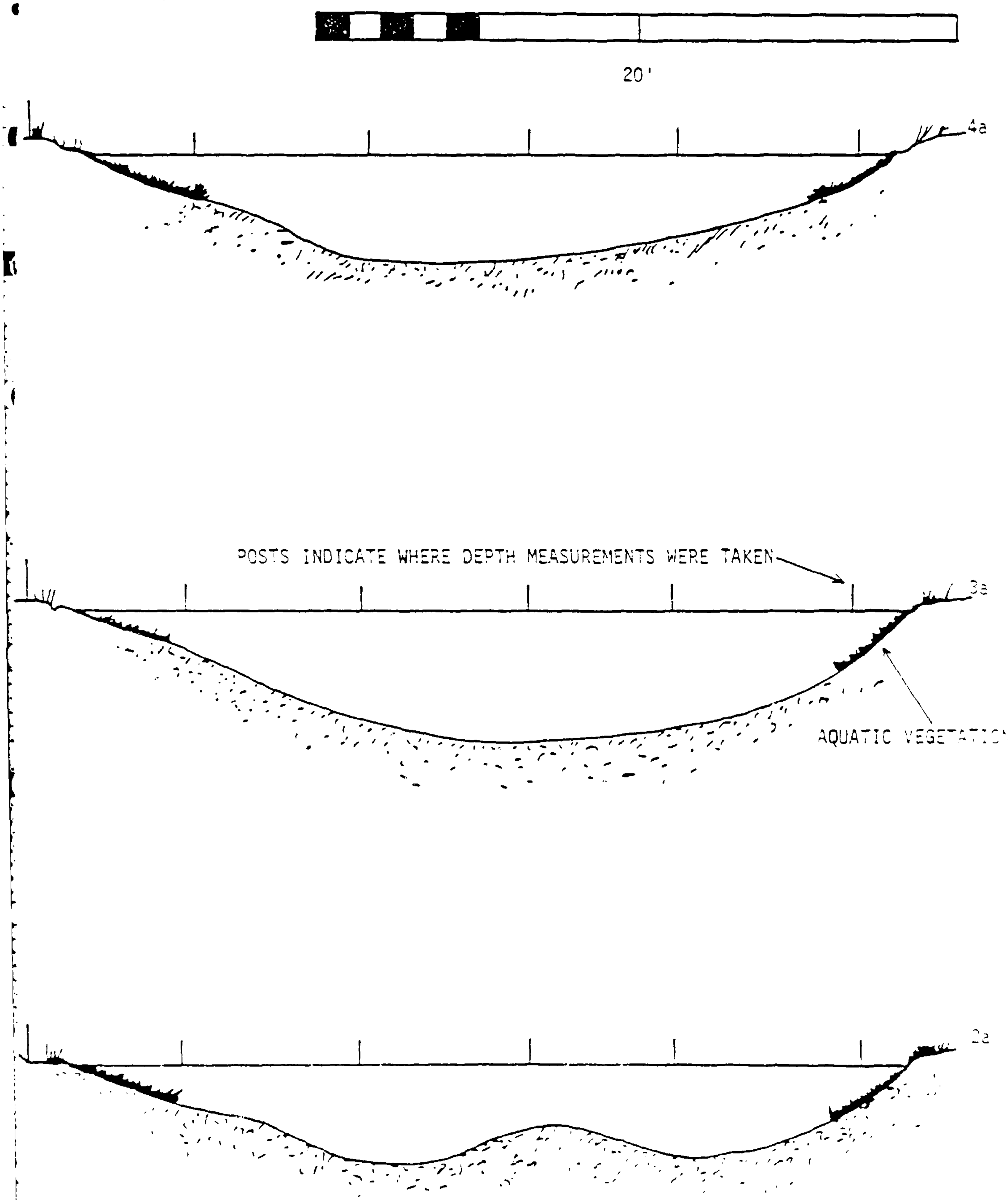
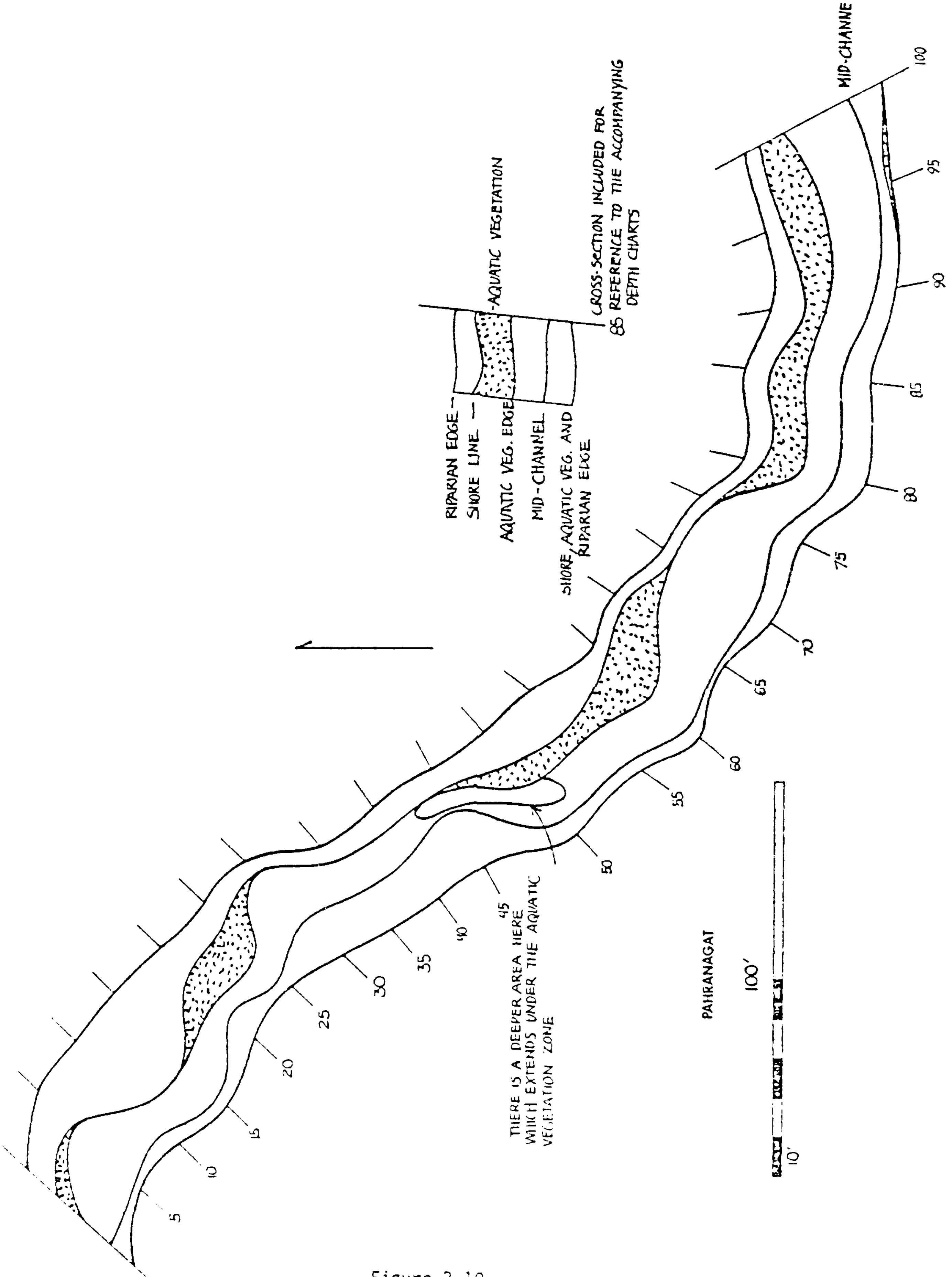

SHOSHONE PONDS
10'
1'
NORTH
FOUR FEET
THREE FEET
TWO FEET
ONE FOOT
END OF AQUATIC VEGETATION
SHORE LINE
1
2
3
4
5
6
7
8
9
10
2a
3a
4a

Figure B-3

Figure B-9. Three cross-sectional transects at Shoshone North Pond.





MID-CHANNE
CROSS-SECTION INCLUDED FOR REFERENCE TO THE ACCOMPANYING DEPTH CHARTS
-AQUATIC VEGETATION
RIPARIAN EDGE
SHORE LINE
AQUATIC VEG. EDGE
MID-CHANNEL
SHORE, AQUATIC VEG. AND RIPARIAN EDGE
THERE IS A DEEPER AREA HERE WHICH EXTENDS UNDER THE AQUATIC VEGETATION ZONE
PAHRANAGAT
100'
10'
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100

Figure 3-10

Figure B-11. Channel development at the outflow of Ash Spring.

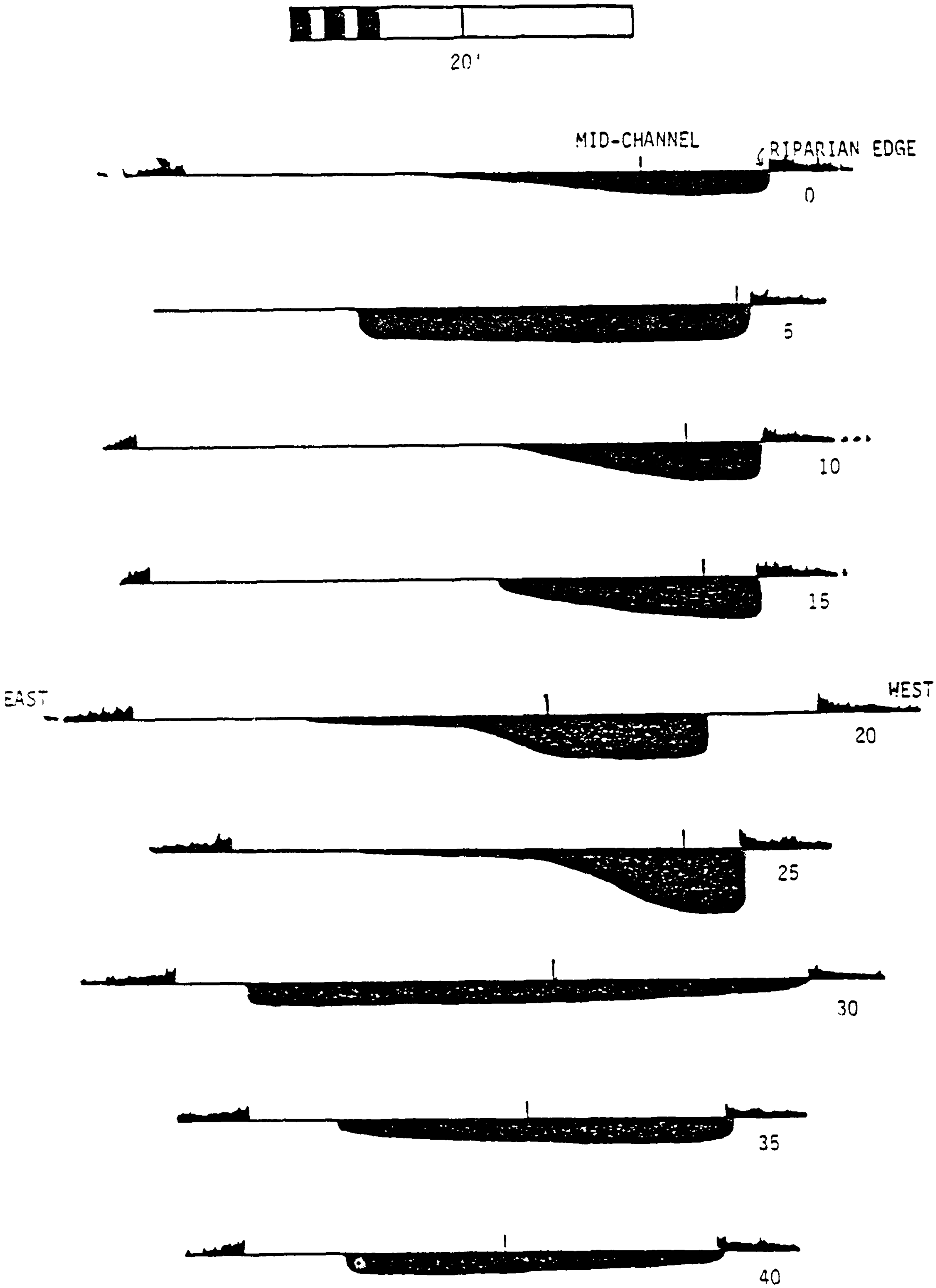


Figure B-12. Channel develocment at the outflow of Ash Soring.

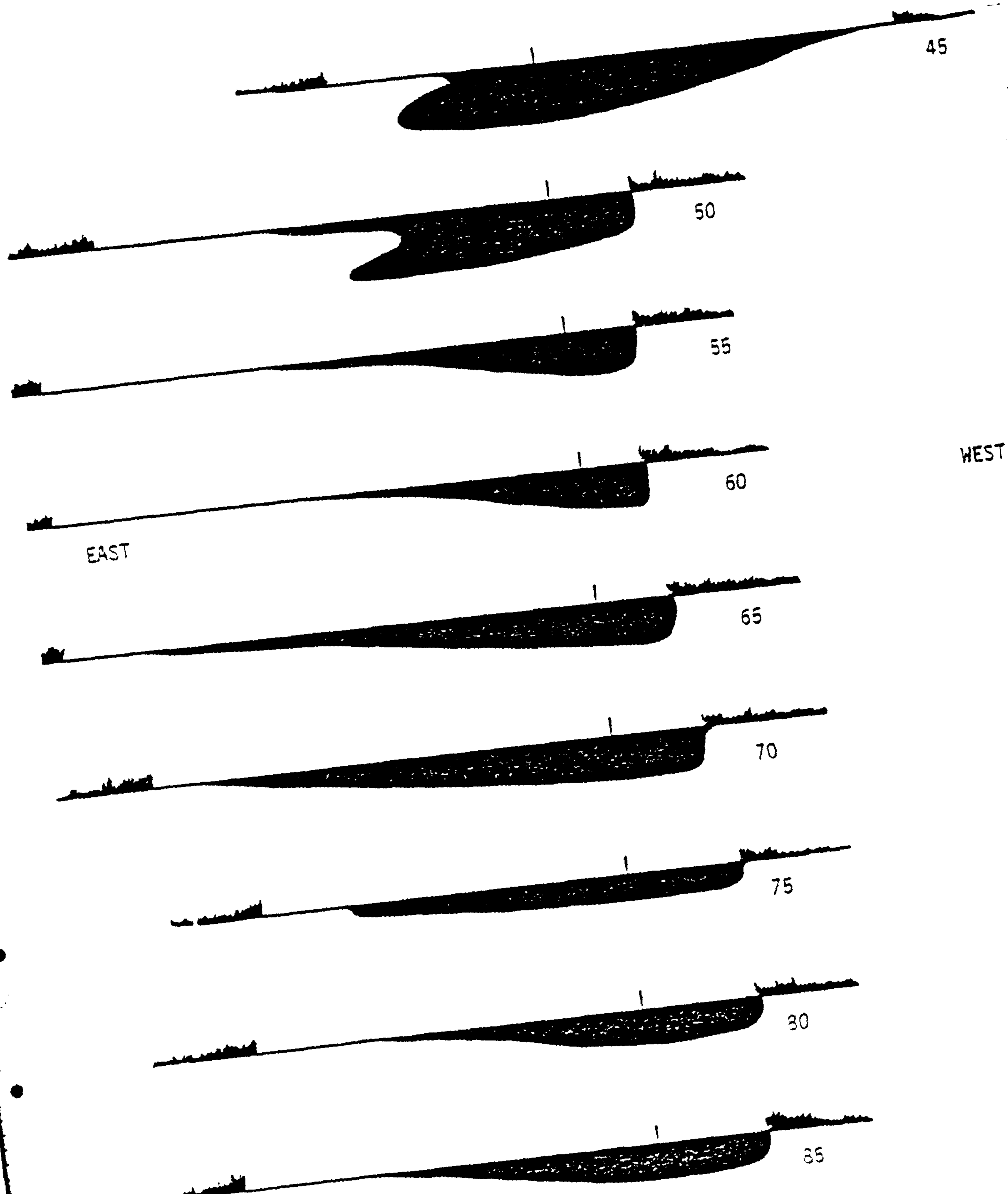


Figure B-13. Channel development at the outflow of Ash Spring.

Photo B-1. Preston Big Spring, June, 1980.

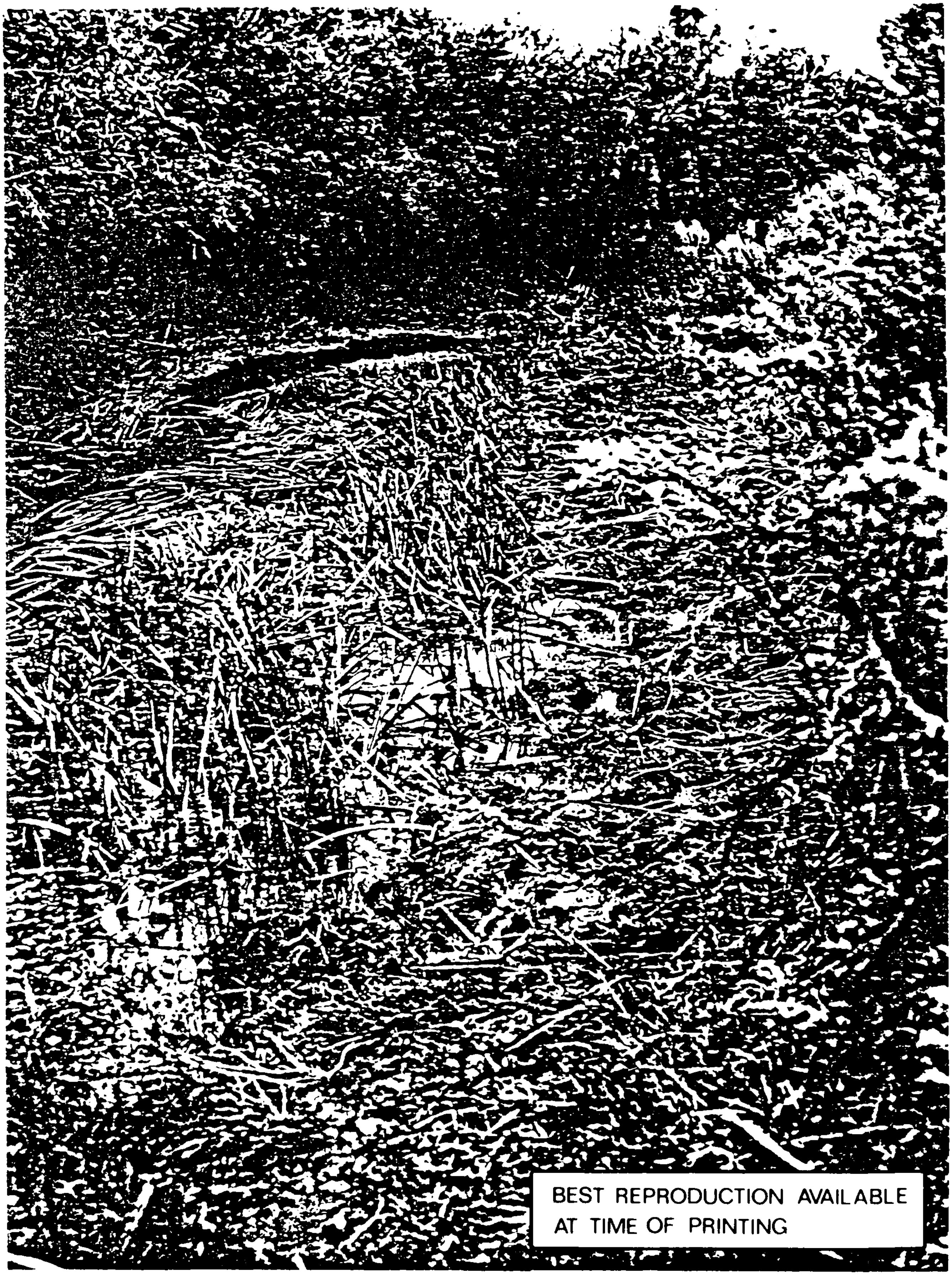


Photo B-2. Preston Big Spring, September, 1980.

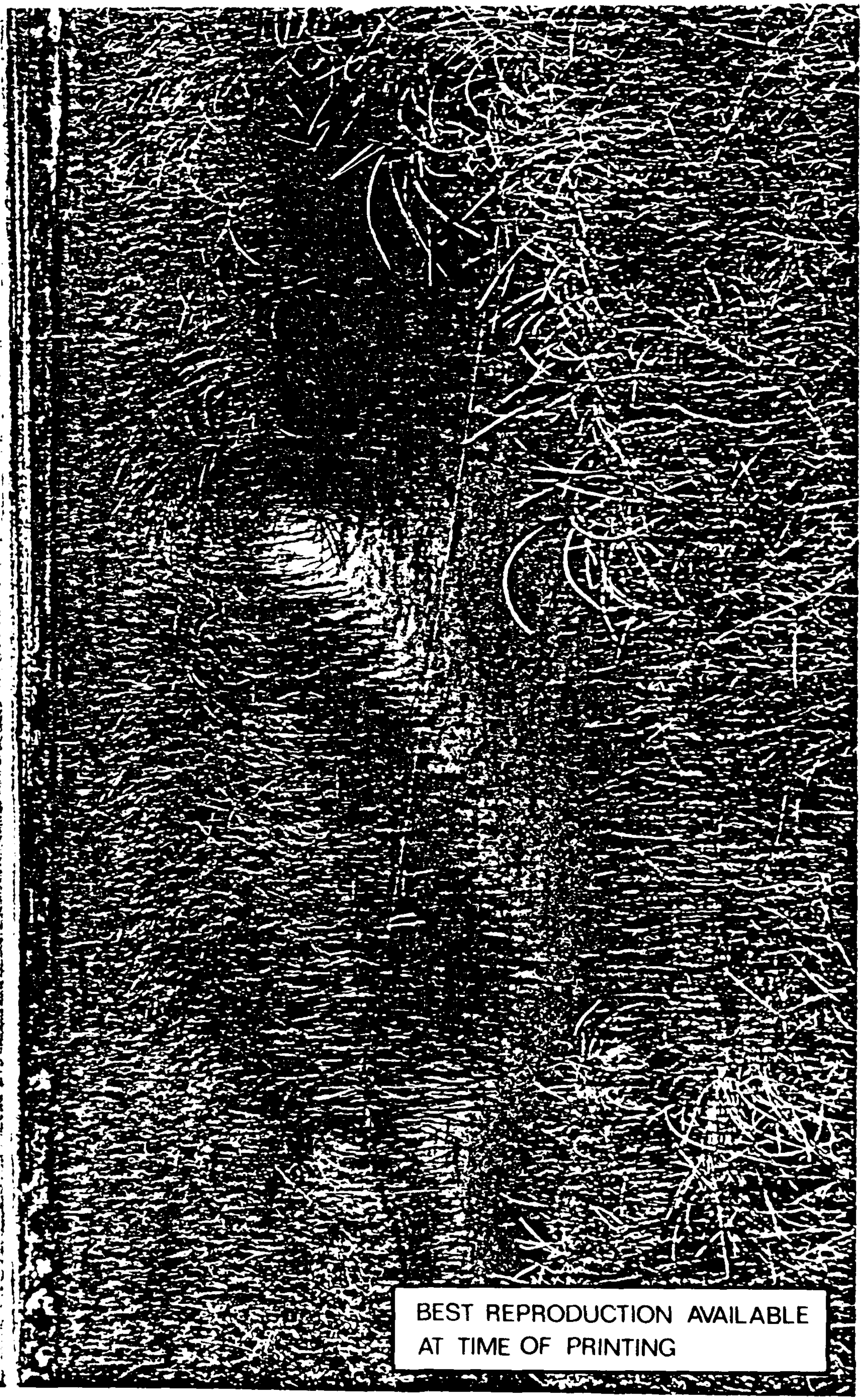


Photo B-3. Lockes Ranch Spring, June, 1980.

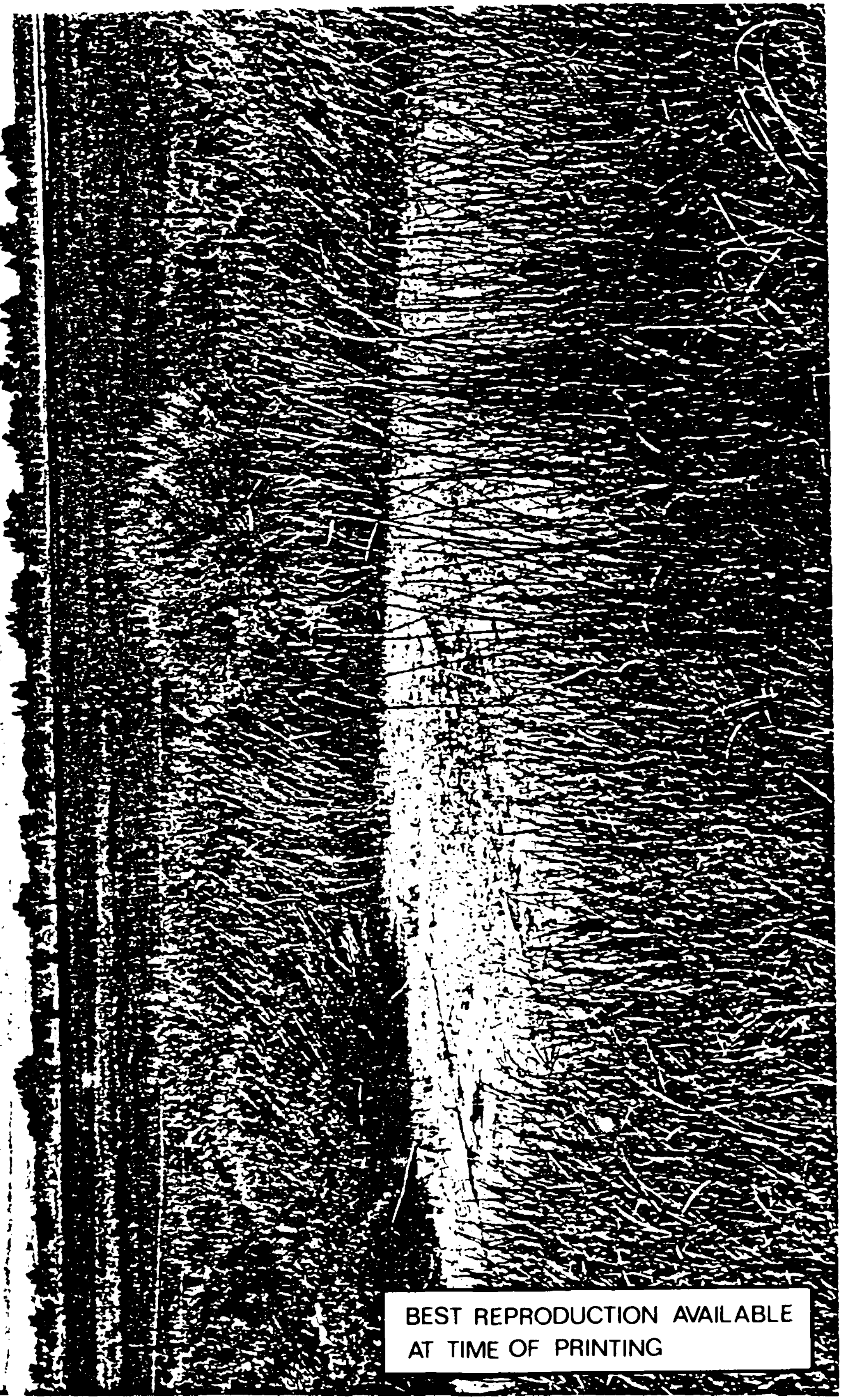


Photo B-4. Shoshone North Pond, June, 1980.

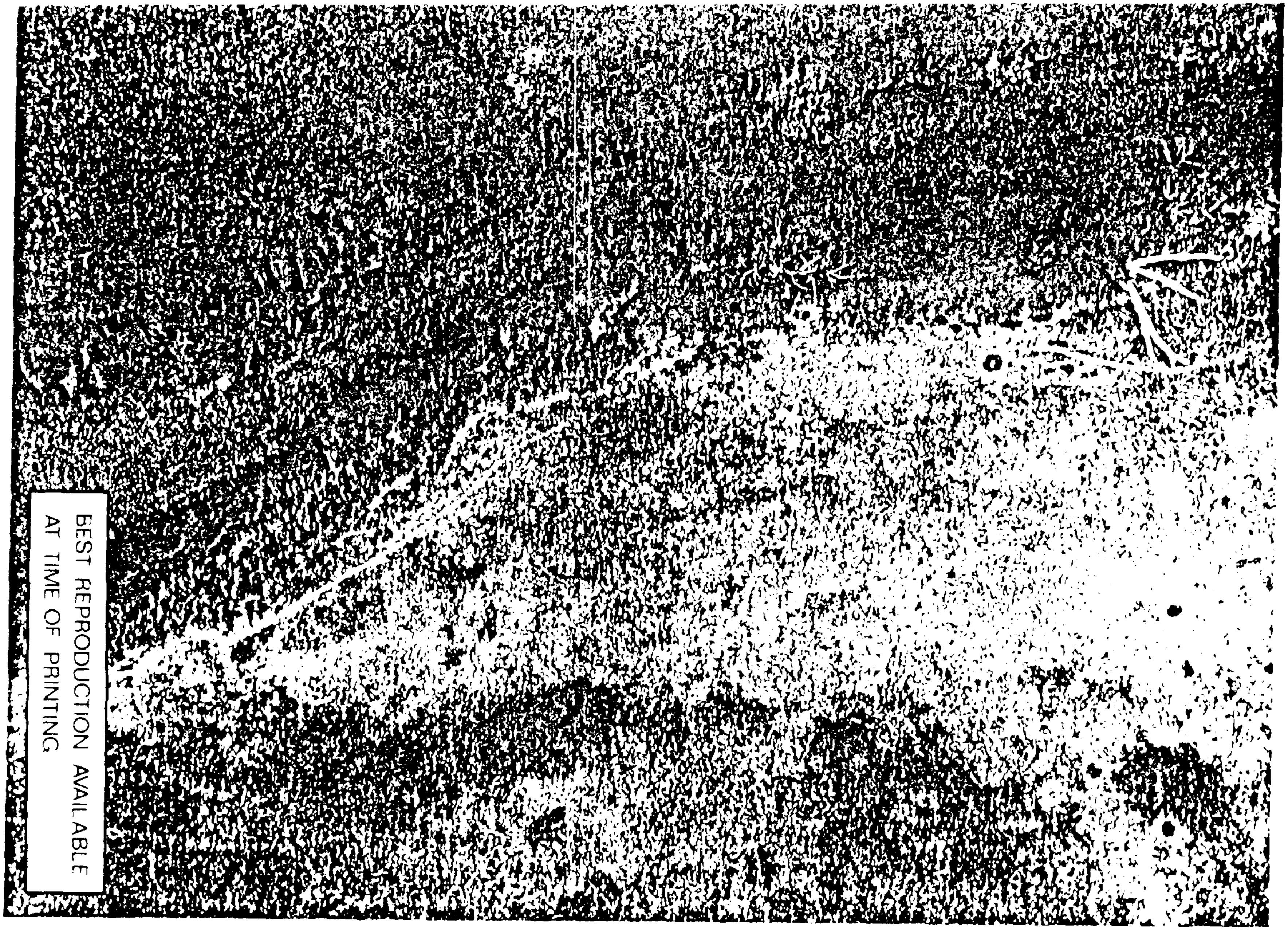


Photo B-5. Outflow of Ash Spring, August, 1980.

APPENDIX C

Raw data tables for invertebrate collections from all springs, June through September. Tables are organized by spring, then date, then habitat type. If there were no animals collected in a sample or if the sample was inadequately preserved, this is indicated in the table. For multiple replicate data sets total counts are presented by replicate and by species. All species are organized within the tables by the taxonomic heirarchy presented in Edmondson, 1959, although current nomenclature was used (eg: Cnidaria rather than Coelenterata). The number following each taxon was assigned for computer identification when the taxon was origionally identified. This number can be used to refer back to the prior draft reports.

Table C-01. - Raw Data For Preston Big Spring, 06/07/80.
Habitat Type: gravel and sand
Animals per meter squared.

Species	Replicates 1	2	3	Total
TURBELLARIA				
turbellaria (probably microturbellaria) (032)	720	32	640	1392
Dugesia sp. (031)	48	288	48	384
OLIGOCHAETA				
Nais sp. a (152)	0	16	0	16
Nais sp. b (153)	0	16	0	16
AMPHIPODA				
Hyalella azteca (001)	112	208	96	416
TRICHOPTERA				
hydroptilidae-unidentifiable larvae (011)	16	0	0	16
Hydroptila sp. - larvae (017)	240	208	64	512
Leucotrichia sp. - larvae (018)	16	0	0	16

(continued)

Table C-01. (cont.)

Species	Replicates 1	2	3	Total
TRICHOPTERA				
Oxyethira sp. - larvae (012)	16	320	112	448
Oxyethira sp. - pupae (013)	96	240	16	352
Oxyethira sp. - adult (014)	32	32	16	80
Stactobiella sp. - larvae (015)	64	32	112	208
LEPIDOPTERA				
Parargyractis sp. (103)	16	0	0	16
DIPTERA				
unidentifiable chironomid larvae (078)	16	16	32	64
Cricotopus spp. - larvae (081)	32	64	320	416
ORIBATEI				
Hydrozetes sp. (101)	0	16	0	16
HYDRACARINA				
Lebertia sp. (102)	0	32	0	32

(continued)

Table C-01. (cont.)

Species	Replicates 1	2	3	Total
GASTROPODA				
Fluminicola n.sp. - sub-adult (052)	0	16	0	16
Fluminicola n.sp. - adult (053)	1920	384	688	2992
Total for 19 taxa	3344	1920	2144	7408

APPENDIX D

Statistics tables for invertebrate collections from all springs, June through September. Tables are organized by spring, then date, then habitat type. If there were no animals collected in a sample or if the sample was inadequately preserved, this is indicated in the table. If only one replicate was collected (Table D-25) only the diversity indices are presented. For multiple replicate data sets diversity indices were calculated by replicate and for totals. All species are organized in the tables by the taxonomic heirarchy presented in Edmondson, 1959, although current nomenclature was used (eg: Cnidaria rather than Coelenterata). The number following each taxon was assigned for computer identification when the taxon was origionally identified. This number can be used to refer back to the prior draft reports. Age groups of a single taxon were combined for the purposes of diversity calculation. For example Oxyethira sp. larvae, pupae, and adults (numbers 12, 13, and 14) were added together prior to diversity index calculation and are presented in the tables as an aggregate. If only one life stage of a species was present in a sample the aggregate is still presented. The number of taxa presented in the tables represents the total number of separable taxonomic groups present in the sample, including different life stages of a single species.

[illegible] of tables are included; the remainder are available [illegible].

Table [illegible]. — Statistics for Preston Big Spring, 06/07/80.
Habitat Type: gravel and sand
Animals per meter squared.

Species	mean	n	std dev	min	max
TURBELLARIA					
turbellaria (probably microturbellaria) (032)	464.000	3	376.255	32.	720.
Dugesia sp. (031)	128.000	3	138.564	48.	288.
OLIGOCHAETA					
Nais sp. a (152)	[illegible].333	3	9.238	0	16.
Nais sp. b (153)	5.333	3	9.238	0	16.
AMPHIPODA					
Hyalella azteca (001)	138.667	3	60.575	96.	208.
TRICHOPTERA					
hydroptilidae-unidentifiable larvae (011)	5.333	3	9.238	0	16.

(continued)

Table D-01. (cont.)

Species	mean	n	std dev	min	max
TRICHOPTERA					
Hydroptila sp. - larvae (017)	170.667	3	93.751	64.	240.
Leucotrichia sp. - larvae (018)	5.333	3	9.238	0	16.
Oxyethira sp. - larvae (012)	149.333	3	155.401	16.	320.
Oxyethira sp. - pupae (013)	117.333	3	113.514	16.	240.
Oxyethira sp. - adult (014)	26.667	3	9.238	16.	32.
Stactobiella sp. - larvae (015)	69.333	3	40.266	32.	112.
LEPIDOPTERA					
Parargyractis sp. (103)	5.333	3	9.238	0	16.
DIPTERA					
unidentifiable chlronomid larvae (078)	21.333	3	9.238	16.	32.

(continued)

Table D-01. (cont.)

Species	mean	n	std dev	min	max
DIPTERA					
Cricotopus spp. - larvae (081)	138.667	3	157.852	32.	320.
ORIBATEI					
Hydrozetes sp. (101)	5.333	3	9.238	0	16.
HYDRACARINA					
Lebertia sp. (102)	10.667	3	18.475	0	32.
GASTROPODA					
Fluminicola n.sp. - sub-adult (052)	5.333	3	9.238	0	16.
Fluminicola n.sp. - adult (053)	997.333	3	813.381	384.	1920.
AGGREGATE					
Aggregate - species numbers 9, 10, 11	5.333	3	9.238	0	16.

(continued)

Table D-01. (cont.)

Species	mean	n	std dev	min	max
AGGREGATE					
Aggregate - species numbers 12, 13, 14	293.333	3	258.653	144.	592.
Aggregate - species numbers 15, 16	69.333	3	40.266	32.	112.
Aggregate - species numbers 17, 19	170.667	3	93.751	64.	240.
Aggregate - species numbers 18, 20, 21	5.333	3	9.238	0	16.
Aggregate - species numbers 51, 52, 53	1002.667	3	807.379	400.	1920.
Aggregate - species numbers 78, 79	21.333	3	9.238	16.	32.
Aggregate - species numbers 81, 88	138.667	3	157.852	32.	320.
Total for 19 species, 3 replicates	2469.333	3	765.719	1920.	3344.

Shannons Diversity Index, replicates 1 - 3 and total 1.978 2.789 2.506 2.653
Brillouns Diversity Index, replicates 1 - 3 and total 1.968 2.768 2.493 2.648

Table D-02. - Statistics For Preston Big Spring, 07/12/80.
Habitat Type: gravel and sand
Animals per meter squared.

Species	mean	n	std dev	min	max
TURBELLARIA					
Dugesia sp. (031)	10.667	3	18.475	0	32.
OLIGOCHAETA					
oligochaeta - all, includes fragments (141)	5.333	3	9.238	0	16.
AMPHIPODA					
Hyalella azteca (001)	16.000	3	27.713	0	48.
COLEOPTERA					
Tropisternus sp. - larvae (038)	5.333	3	9.238	0	16.
TRICHOPTERA					
Hydroptila sp. - adult (019)	74.667	3	60.575	32.	144.

(continued)

Table D-02. (cont.)

Species	mean	n	std dev	min	max
TRICHOPTERA					
Leucotrichia sp. - larvae (018)	234.667	3	171.083	128.	432.
Leucotrichia sp. - adult (020)	21.333	3	24.440	0	48.
Stactobiella sp. - larvae (015)	64.000	3	57.689	16.	128.
Stactobiella sp. - pupae (016)	170.667	3	75.613	112.	256.
DIPTERA					
unidentifiable dipteran larvae (098)	5.333	3	9.238	0	16.
unidentified chironomid - larvae * (072)	26.667	3	18.475	16.	48.
Limonia sp. - larvae (097)	10.667	3	18.475	0	32.
HYDRACARINA					
Lebertia sp. (102)	5.333	3	9.238	0	16.

(continued)

Table D-02. (cont.)

Species	mean	n	std dev	min	max
AGGREGATE					
Aggregate - species numbers 15, 16	234.667	3	133.227	128.	384.
Aggregate - species numbers 17, 19	74.667	3	60.575	32.	144.
Aggregate - species numbers 18, 20, 21	256.000	3	194.648	128.	480.
Aggregate - species numbers 37, 38, 183	5.333	3	9.238	0	16.
Aggregate - species numbers 70, 71, 72	26.667	3	18.475	16.	48.
Aggregate - species numbers 98, 99	5.333	3	9.238	0	16.
Total for 13 species, 3 replicates	650.667	3	449.806	352.	1168.

Shannons Diversity Index, replicates 1 - 3 and total 1.971 1.755 2.155 2.161
Brillouns Diversity Index, replicates 1 - 3 and total 1.931 1.724 2.133 2.144

Table D-03. - Statistics For Preston Big Spring, 08/09/80.
Habitat Type: gravel and sand
Animals per meter squared.

Species	mean	n	std dev	min	max
TURBELLARIA					
Dugesia sp. (031)	58.667	3	60.575	16.	128.
AMPHIPODA					
Hyalella azteca (001)	16.000	3	16.000	0	32.
ODONATA					
immature libellulidae (045)	5.333	3	9.238	0	16.
Tarnetrum corruptum (041)	5.333	3	9.238	0	16.
TRICHOPTERA					
hydroptilidae-unidentifiable larvae (011)	16.000	3	16.000	0	32.

(continued)

Table D-03. (cont.)

Species	mean	n	std dev	min	max
TRICHOPTERA					
hydroptilidae - adult (010)	5.333	3	9.238	0	16.
Leucotrichia sp. - larvae (018)	1061.333	3	190.886	848.	1216.
Leucotrichia sp. - adult (020)	746.667	3	169.580	592.	928.
Stactobiella sp. - larvae (015)	5.333	3	9.238	0	16.
DIPTERA					
Simulium sp. - larvae (169)	10.667	3	18.475	0	32.
HYDRACARINA					
Lebertia sp. (102)	5.333	3	9.238	0	16.
GASTROPODA					
Fluminicola n.sp. - juvenile (051)	10.667	3	18.475	0	32.

(continued)

Table D-03. (cont.)

Species	mean	n	std dev	min	max
GASTROPODA					
Fluminicola n.sp. - sub-adult (052)	186.667	3	40.266	144.	224.
Fluminicola n.sp. - adult (053)	3706.667	3	1349.354	2432.	5120.
AGGREGATE					
Aggregate - species numbers 9, 10, 11	21.333	3	9.238	16.	32.
Aggregate - species numbers 15, 16	5.333	3	9.238	0	16.
Aggregate - species numbers 18, 20, 21	1808.000	3	323.580	1440.	2048.
Aggregate - species numbers 51, 52, 53	3904.000	3	1322.495	2688.	5312.
Total for 14 species, 3 replicates	5840.000	3	1470.869	4784.	7520.

Shannons Diversity Index, replicates 1 - 3 and total .958 1.250 1.003 1.085
Brillouns Diversity Index, replicates 1 - 3 and total .959 1.248 1.005 1.087

Table D-04. - Statistics For Preston Big Spring, 09/06/80.
Habitat Type: gravel and sand
Animals per meter squared.

Species	mean	n	std dev	min	max
TURBELLARIA *Dugesia* sp. (031)	261.333	3	181.960	112.	464.
AMPHIPODA *Hyalella azteca* (001)	1402.667	3	955.501	544.	2432.
EPHEMEROPTERA *Callibaetis* sp. (027)	5.333	3	9.238	0	16.
ODONATA *Argia* spp. (042)	96.000	3	27.713	80.	128.
TRICHOPTERA hydroptilidae - unidentifiable pupae (009)	32.000	3	42.332	0	80.

(continued)

Table D-04. (cont.)

Species	mean	n	std dev	min	max
TRICHOPTERA					
hydroptilidae - adult (010)	10.667	3	18.475	0	32.
Hydroptila sp. - larvae (017)	10.667	3	18.475	0	32.
Leucotrichia sp. - larvae (018)	2341.333	3	661.699	1616.	2912.
Leucotrichia sp. - pupae (021)	1888.000	3	89.084	1808.	1984.
Oxyethira sp. - larvae (012)	16.000	3	16.000	0	32.
Stactobiella sp. - larvae (015)	48.000	3	32.000	16.	80.
LEPIDOPTERA					
Parargyractis sp. (103)	37.333	3	40.266	0	80.
DIPTERA					
unidentified chironomid - larvae * (072)	85.333	3	93.751	16.	192.

(continued)

Table D-04. (cont.)

Species	mean	n	std dev	min	max
DIPTERA					
<u>Simuliium</u> sp. - larvae (169)	10.667	3	9.238	0	16.
ceratopogonidae - pupae (172)	5.333	3	9.238	0	16.
HYDRACARINA					
<u>Lebertia</u> sp. (102)	16.000	3	16.000	0	32.
AGGREGATE					
Aggregate - species numbers 9, 10, 11	42.667	3	60.575	0	112.
Aggregate - species numbers 12, 13, 14	16.000	3	16.000	0	32.
Aggregate - species numbers 15, 16	48.000	3	32.000	16.	80.
Aggregate - species numbers 17, 19	10.667	3	18.475	0	32.
Aggregate - species numbers 18, 20, 21	4229.333	3	653.132	3488.	4720.

(continued)

Table D-04. (cont.)

Species	mean	n	std dev	min	max
AGGREGATE					
Aggregate - species numbers 70, 71, 72	85.333	3	93.751	16.	192.
Total for 16 species, 3 replicates	6266.667	3	1461.732	4736.	7648.

Shannons Diversity Index, replicates 1 - 3 and total 1.368 1.550 1.247 1.474
Brillouns Diversity Index, replicates 1 - 3 and total 1.364 1.549 1.245 1.475

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UNCLASSIFIED M-X-ETR-17-VOL-2 F/G 6/3 NL

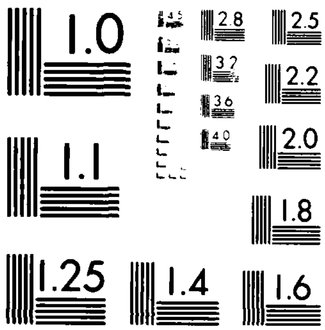

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Table D-05. - Statistics For Preston Big Spring, 06/07/80.
Habitat Type: nasturtium mat
Animals per meter squared.

Species	mean	n	std dev	min	max
CNIDARIA					
Chlorohydra viridissima (033)	229.333	3	330.365	0	608.
TURBELLARIA					
turbellaria (probably microturbellaria) (032)	410.667	3	218.406	160.	560.
Dugesia sp. (031)	4378.667	3	3302.066	1440.	7952.
NEMATODA					
nematoda (161)	10.667	3	18.475	0	32.
OLIGOCHAETA					
immature tubificid without hair chaete (146)	5.333	3	9.238	0	16.

(continued)

APPENDIX E

Tables and figures associated with fish population analysis at Preston Big, Lockes Ranch, Shoshone North Pond, and the outflow of Ash springs, June through September, 1980.

Table E-1. Visual Counts of Fish at Pahranagat (outflow of Ash Spring). June, 1980. 1 = First Count 2 = Second Count

TRANSECT NO.	G.R.* 1	G.R.* 2	R.O.* 1	R.O.* 2	C.N.* 1	C.N.* 2	P.M.* 1	P.M.* 2	G.A.* 1	G.A.* 2	MISCELLANEOUS
00-05	4	2	52	27	30	25	188	289	25	28	
05-10	0	2	22	22	42	25	94	83	65	78	
10-15	2	3	9	19	35	33	9	12	9	7	
15-20	11	9	17	18	59	47	51	32	0	0	
20-25	21	29	223	197	17	19	31	24	0	0	
25-30	18	12	55	62	48	45	155	159	10	10	3 Crenichtys
30-35	1	1	3	23	48	67	187	185	11	20	
35-40	0	0	3	9	43	31	108	118	16	15	
40-45	1	0	35	41	41	79	44	51	26	29	
45-50	41	44	64	55	7	13	8	6	0	0	
50-55	1	1	7	0	27	25	14	0	9	9	
55-60	3	2	101	78	17	47	12	9	8	12	
60-65	5	8	60	73	70	45	127	105	29	0	
65-70	2	3	62	44	23	23	122	63	24	22	
70-75	4	1	34	12	47	72	114	126	30	41	
75-80	0	2	9	21	61	83	99	98	42	45	1 Carp
80-85	4	4	4	2	62	37	73	53	3	4	
85-90	2	2	6	8	72	41	64	44	2	1	
90-95	0	1	11	29	22	38	51	60	0	0	1 Crenichthys
95-100	3	3	29	23	57	77	57	71	3	5	1 Carp

* G.R. = Gila robusta jordani
R.O. = Rhinichthys osculus
C.N. = Cichlasoma nigrofaciatum
P.M. = Poecilia mexicana
G.A. = Gambusia affinis

Table E-2. Visual Counts of Fish at Pahranagat (outflow of Ash Spring). July, 1980. 1 = First Count, 2 = Second Count.

TRANSECT	G.R.*		R.O.*		C.N.*		P.M.*		G.A.*		MISCELLANEOUS
NO.	1	2	1	2	1	2	1	2	1	2	
00-05	7	5	37	7	226	51	323	326	34	42	
05-10	6	3	13	26	134	39	167	109	81	104	1 Crenichthys
10-15	1	5	15	12	99	34	50	71	62	75	
15-20	0	4	23	5	35	18	18	33	0	0	
20-25	6	3	67	66	99	16	71	79	0	0	1 Crenichthys
25-30	15	2	9	17	87	24	93	51	8	0	
30-35	0	8	19	15	61	69	121	89	18	24	
35-40	2	1	5	7	51	39	83	78	11	8	
40-45	56	60	40	3	5	63	10	64	25	38	
45-50	1	2	20	48	34	6	46	18	11	21	
50-55	0	0	20	4	43	15	54	31	5	9	
55-60	12	16	121	42	41	25	38	26	10	15	2 Crenichthys
60-65	4	15	52	52	41	42	56	52	16	15	
65-70	3	1	34	18	41	90	92	31	20	25	
70-75	1	2	3	2	54	85	155	60	35	32	
75-80	2	5	3	4	71	49	133	58	35	44	
80-85	1	5	4	2	36	74	78	68	9	17	
85-90	1	8	4	0	57	100	117	172	5	11	
90-95	3	5	6	2	68	101	98	152	12	30	
95-100	3	4	11	1	90	67	78	45	0	15	

* G.R. = Gila robusta jordani
R.O. = Rhinichthys osculus
C.N. = Cichlasoma nigrofaciatum
P.M. = Poecilia mexicana
G.A. = Gambusia affinis

Table E-3. Visual Counts of Fish at Pahranagat (outflow of Ash Spring). *August, 1980. 1 = First Count.*

TRANSECT NO.	G.R.* 1	R.O.* 1	C.N.* 1	P.M.* 1	G.A.* 1	MISCELLANEOUS
00-05	18	6	113	63	120	
05-10	0	1	122	110	26	
10-15	3	0	67	113	0	
15-20	0	0	14	15	0	
20-25	0	12	27	6	11	
25-30	1	21	40	38	48	
30-35	9	14	58	48	22	
35-40	5	0	151	126	25	
40-45	3	0	57	116	30	
45-50	76	31	39	19	9	1 Carp
50-55	1	0	25	24	6	
55-60	0	0	12	12	25	
60-65	9	47	36	18	68	
65-70	0	0	38	17	33	1 Crenichthys
70-75	0	1	88	81	30	
75-80	3	0	132	161	31	
80-85	3	0	64	141	0	
85-90	4	0	69	177	67	
90-95	2	0	135	143	0	1 Crenichthys
95-100	1	2	90	134	0	

* G.R. = Gila robusta jordani
R.O. = Rhinichthys osculus
C.N. = Cichlasoma *nigrofaciatum*
P.M. = Poecilia mexicana
G.A. = Gambusia affinis

Table E-4. Visual Counts of Fish at Pahranagat (outflow of Ash Spring). September, 1980. 1 = First Count, 2 = Second Count.

TRANSECT	G.R.*		R.O.*		C.N.*		P.M.*		G.A.*		MISCELLANEOUS
NO.	1	2	1	2	1	2	1	2	1	2	
00-05	3	5	0	0	154	80	149	95	46	10	
05-10	0	0	0	0	83	78	60	79	0	14	
10-15	0	0	0	0	21	36	5	18	0	0	
15-20	0	0	0	0	27	17	5	9	0	0	
20-25	0	0	0	0	17	40	0	9	0	45	
25-30	0	2	0	0	20	9	25	23	1	4	1 Carp
30-35	4	7	12	0	78	39	73	77	15	55	
35-40	11	14	1	1	148	45	115	51	10	11	
40-45	0	0	0	0	94	83	66	39	0	2	
45-50	31	36	3	7	50	47	53	38	27	24	
50-55	0	0	0	0	23	18	40	12	4	57	
55-60	4	2	34	24	7	12	13	18	2	37	
60-65	0	0	2	1	14	25	12	27	107	63	
65-70	0	0	0	0	28	32	50	22	30	36	
70-75	0	0	0	0	72	70	88	41	30	22	
75-80	2	0	1	0	31	23	112	56	20	18	
80-85	0	0	0	0	21	21	64	109	10	4	
85-90	0	0	0	0	32	22	33	55	9	0	
90-95	0	0	0	0	45	29	40	49	0	4	
95-100	3	1	0	0	26	74	33	90	2	12	

* G.R. = Gila robusta jordani
R.O. = Rhinichthys osculus
C.N. = Cichlasoma nigrofaciatum
P.M. = Poecilia mexicana
G.A. = Gambusia affinis

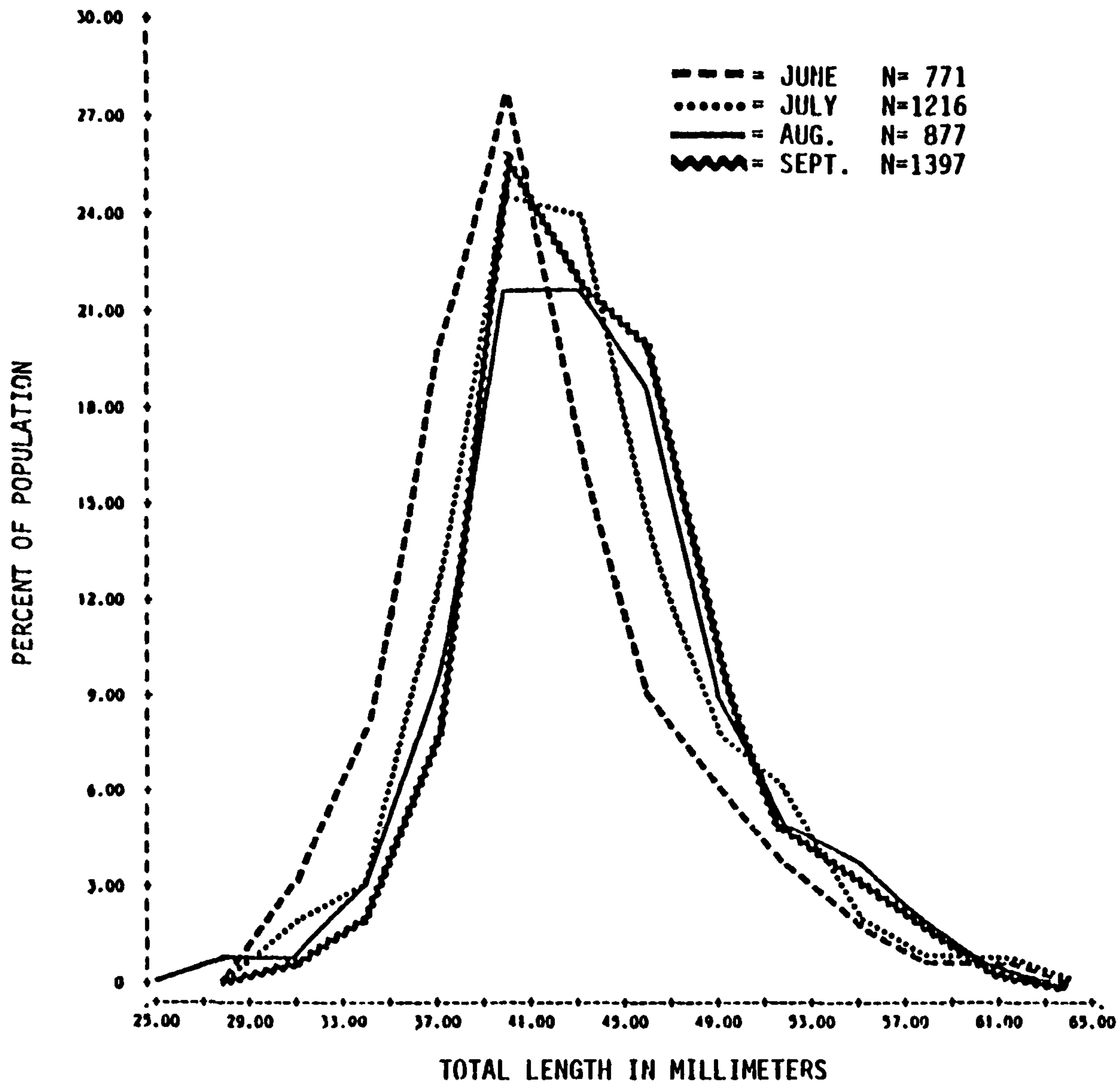


Fig. E-1. Population structure of *Rhinichthys osculus* during June through September, 1980, at Preston Big Spring.

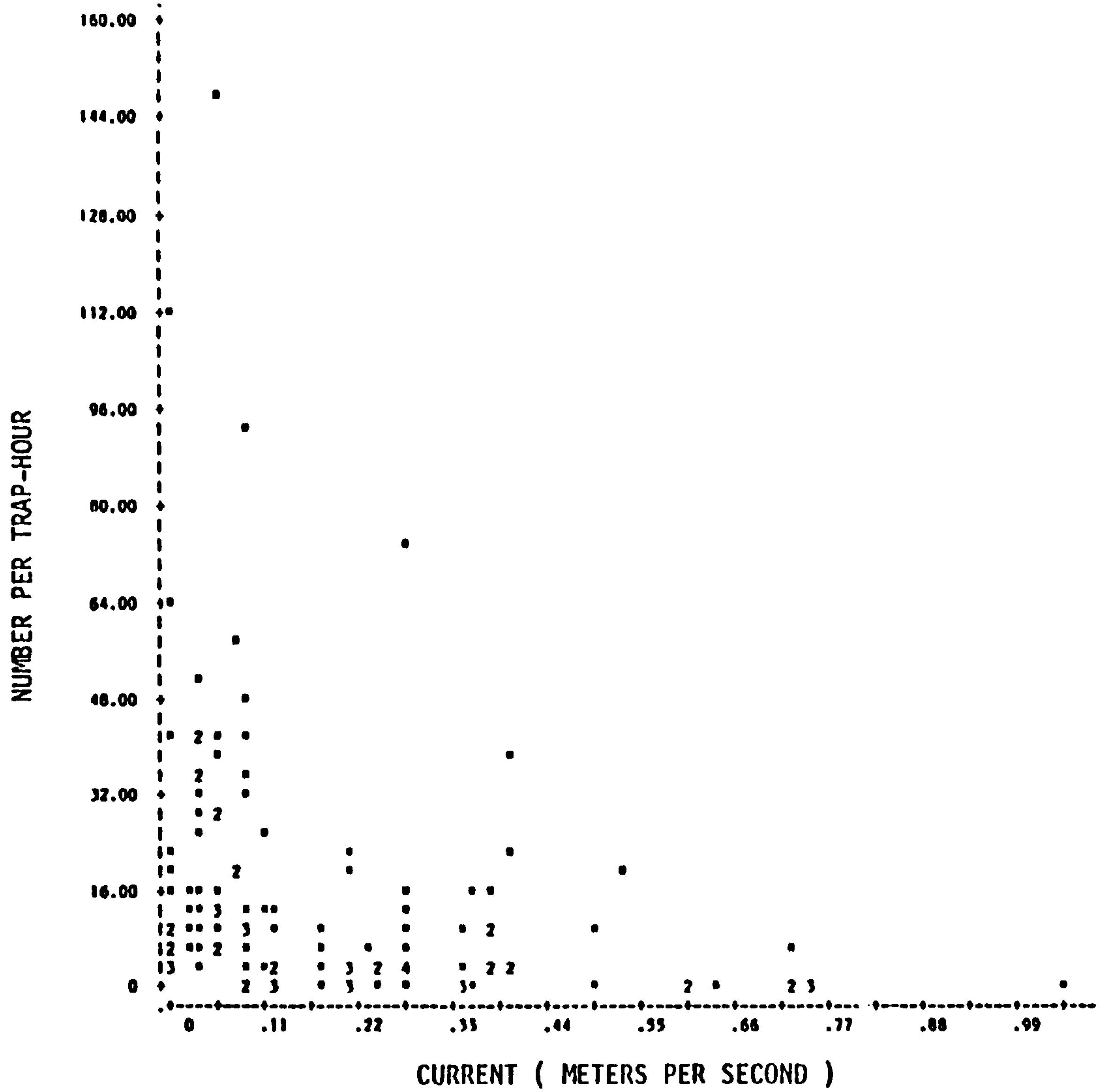


Fig. E-2. Response of Rhinichthys osculus to current during July through September, 1980, at Preston Big Spring.

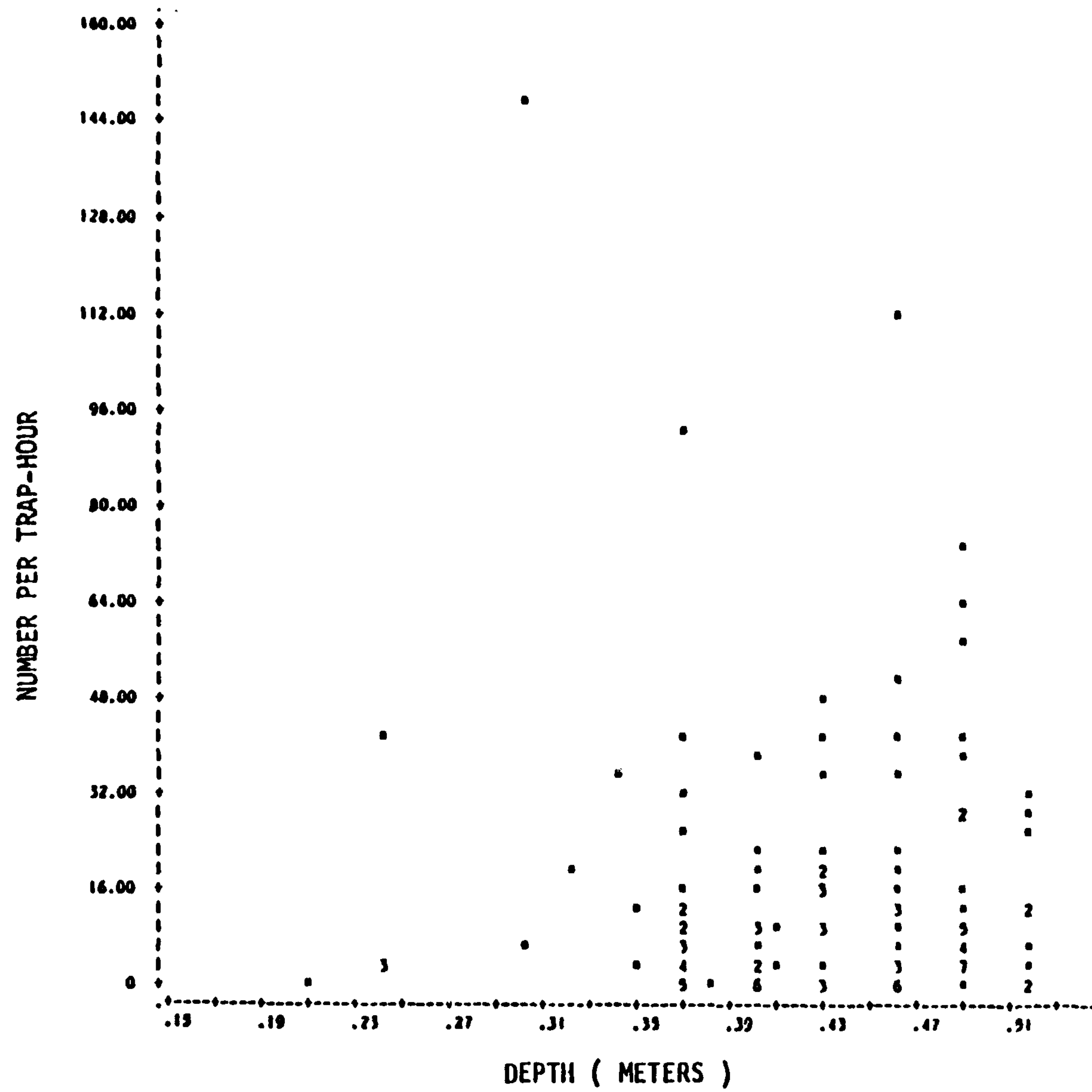


Fig. E-3. Response of <u>Rhinichthys</u> <u>osculus</u> to depth during July through September, 1980, at Preston Big Spring.

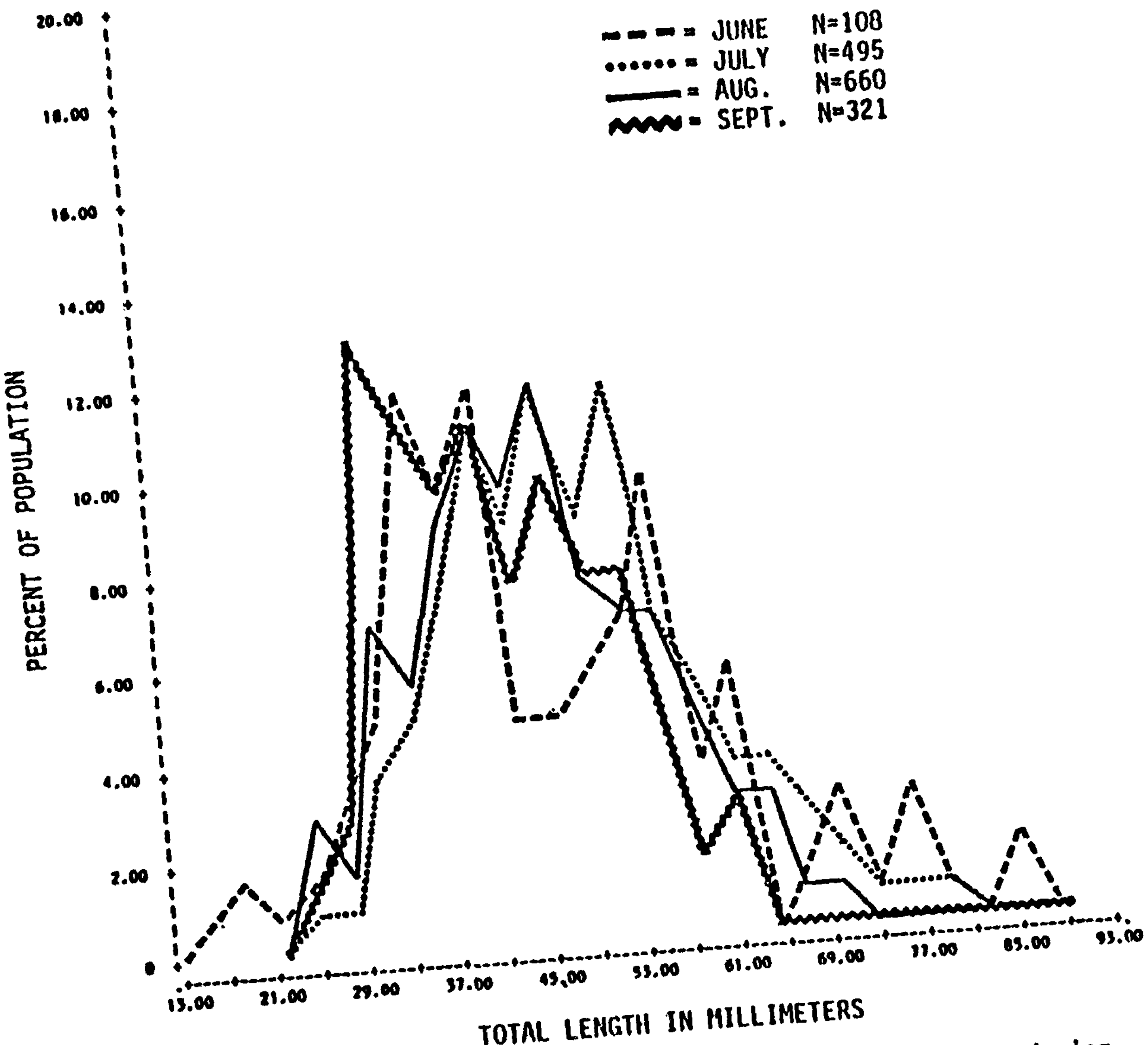


Fig. E-4. Population structure of <u>Crenichthys baileyi</u> during June through September, 1980, at Preston Big Spring.

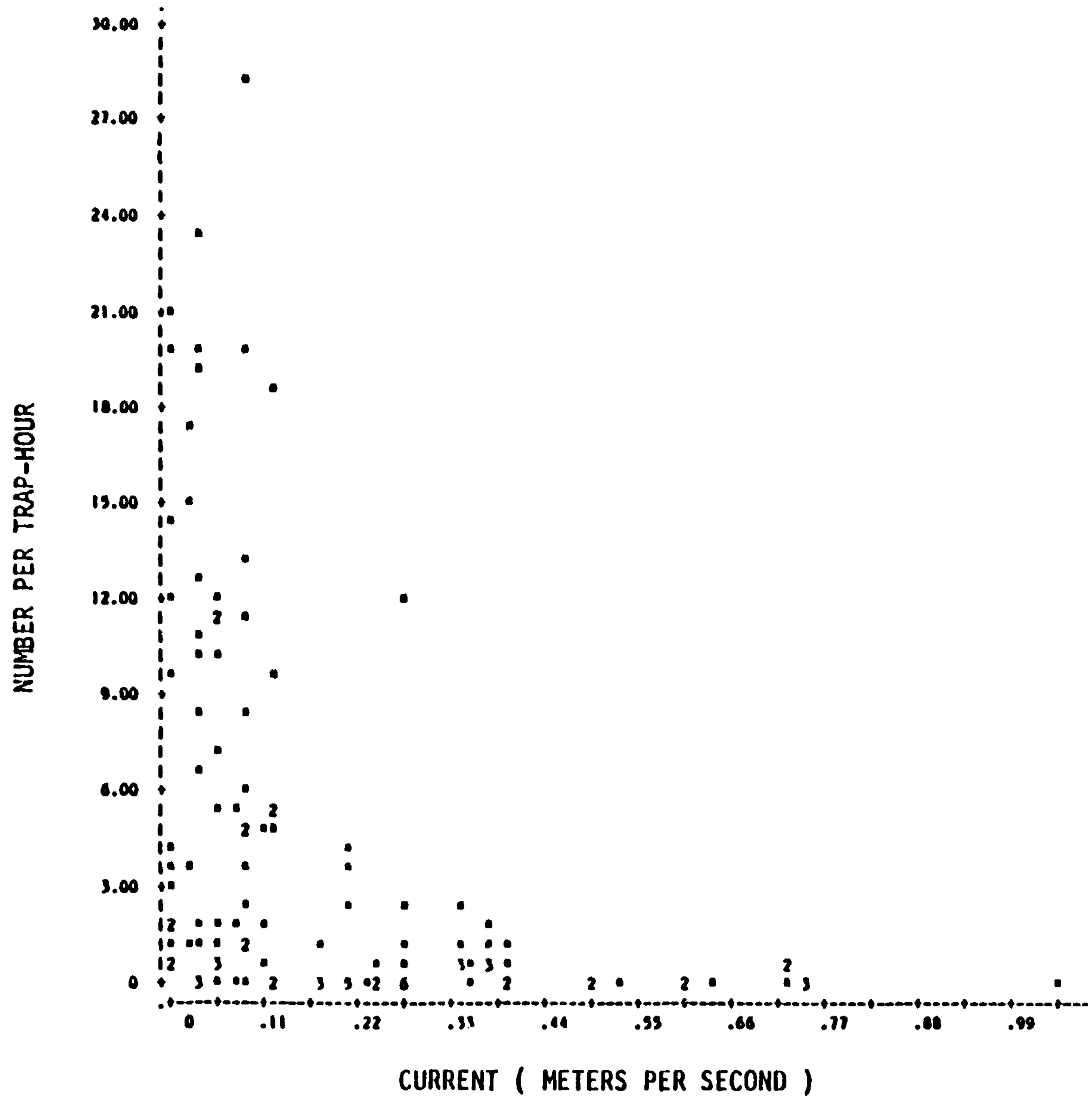


Fig. E-5. Response of Crenichthys baileyi to current during July through September, 1980, at Preston Big Spring.

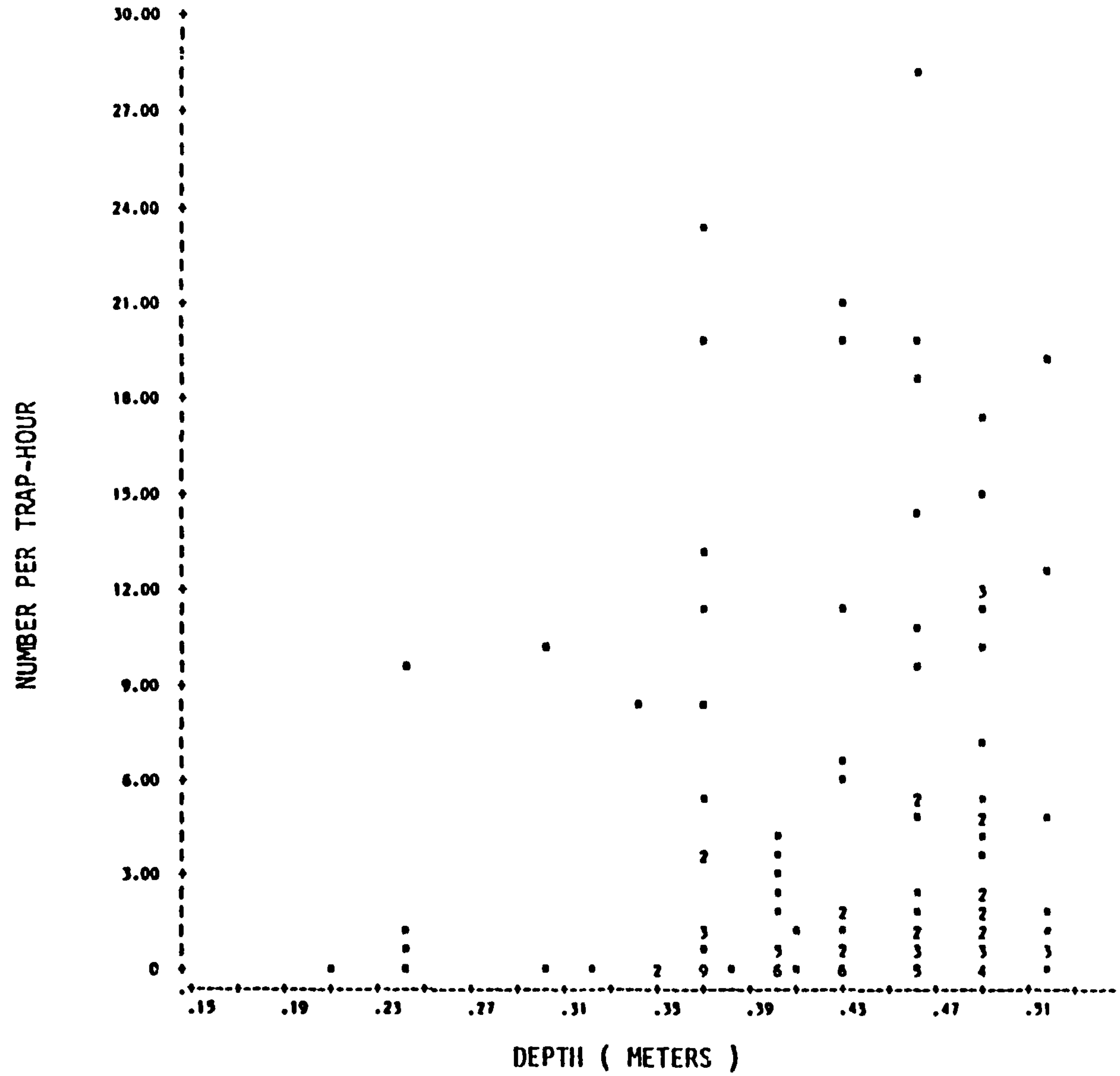


Fig. E-6. Response of Crenichthys baileyi to depth during July through September, 1980, at Preston Big Spring.

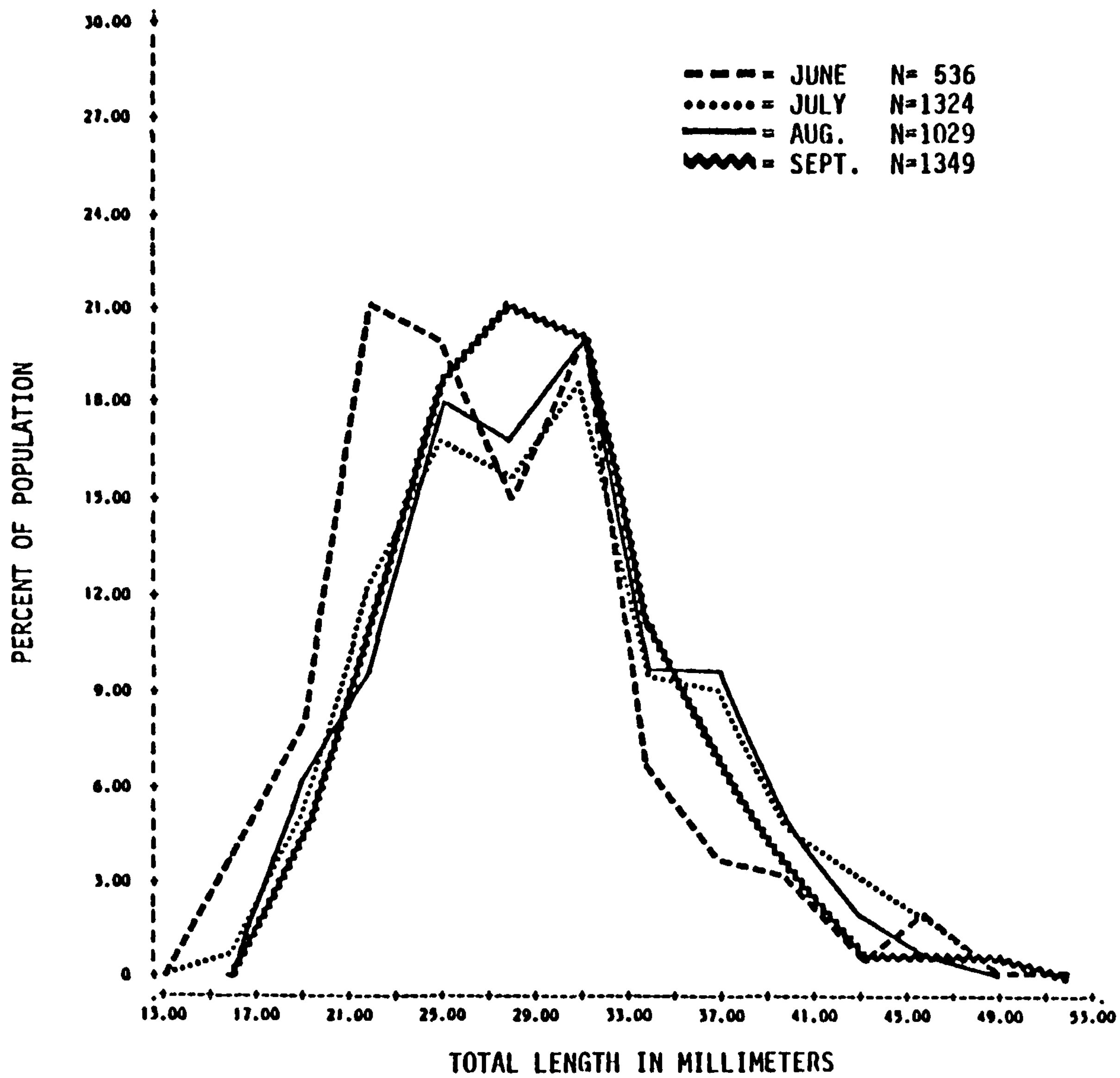


Fig. E-7. Population structure of Crenichthys nevadae during June through September, 1980, at Lockes Ranch Spring.

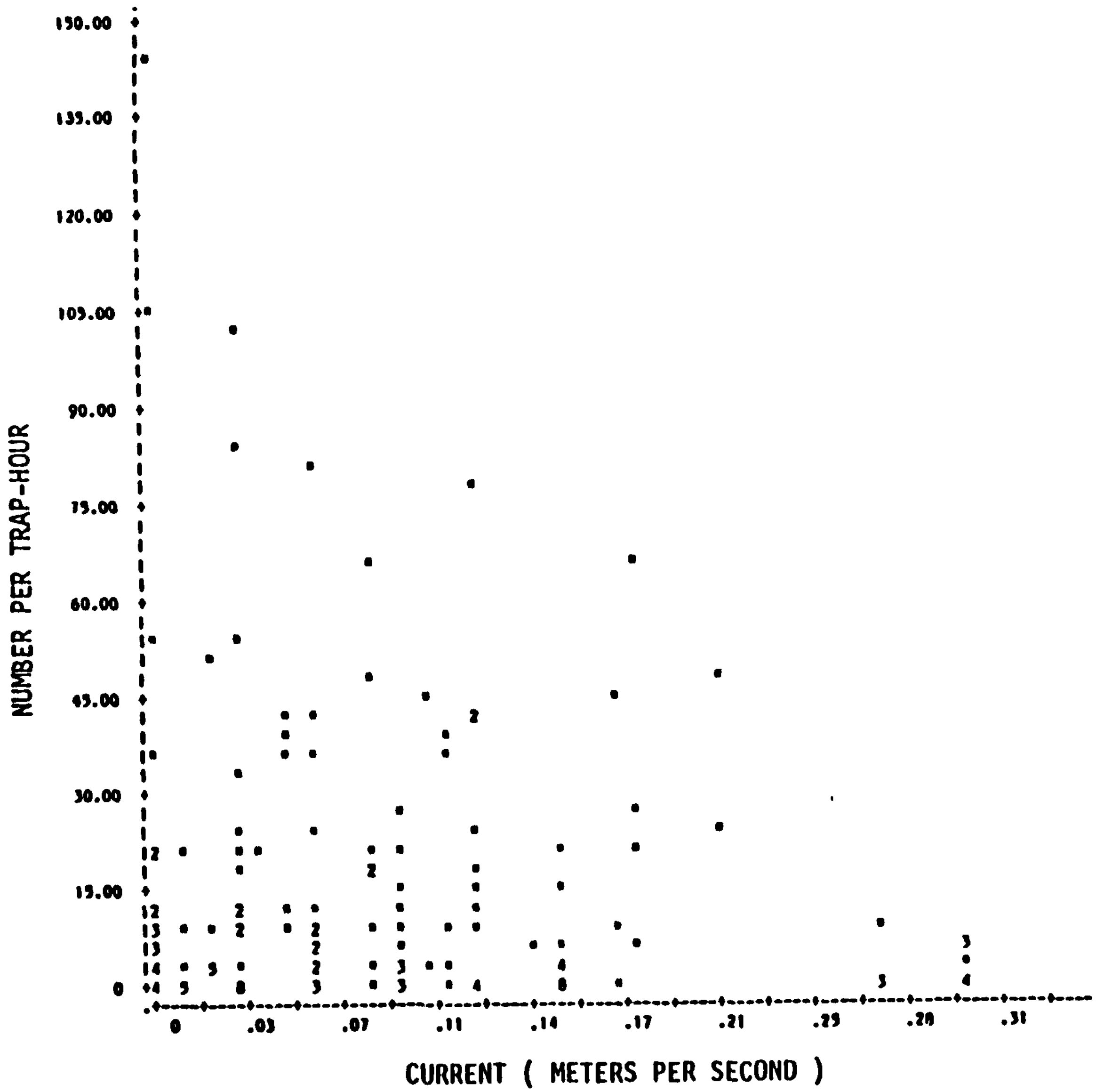


Fig. E-8. Response of Crenichthys nevadae to current during July through September, 1980, at Lockes Ranch Spring.

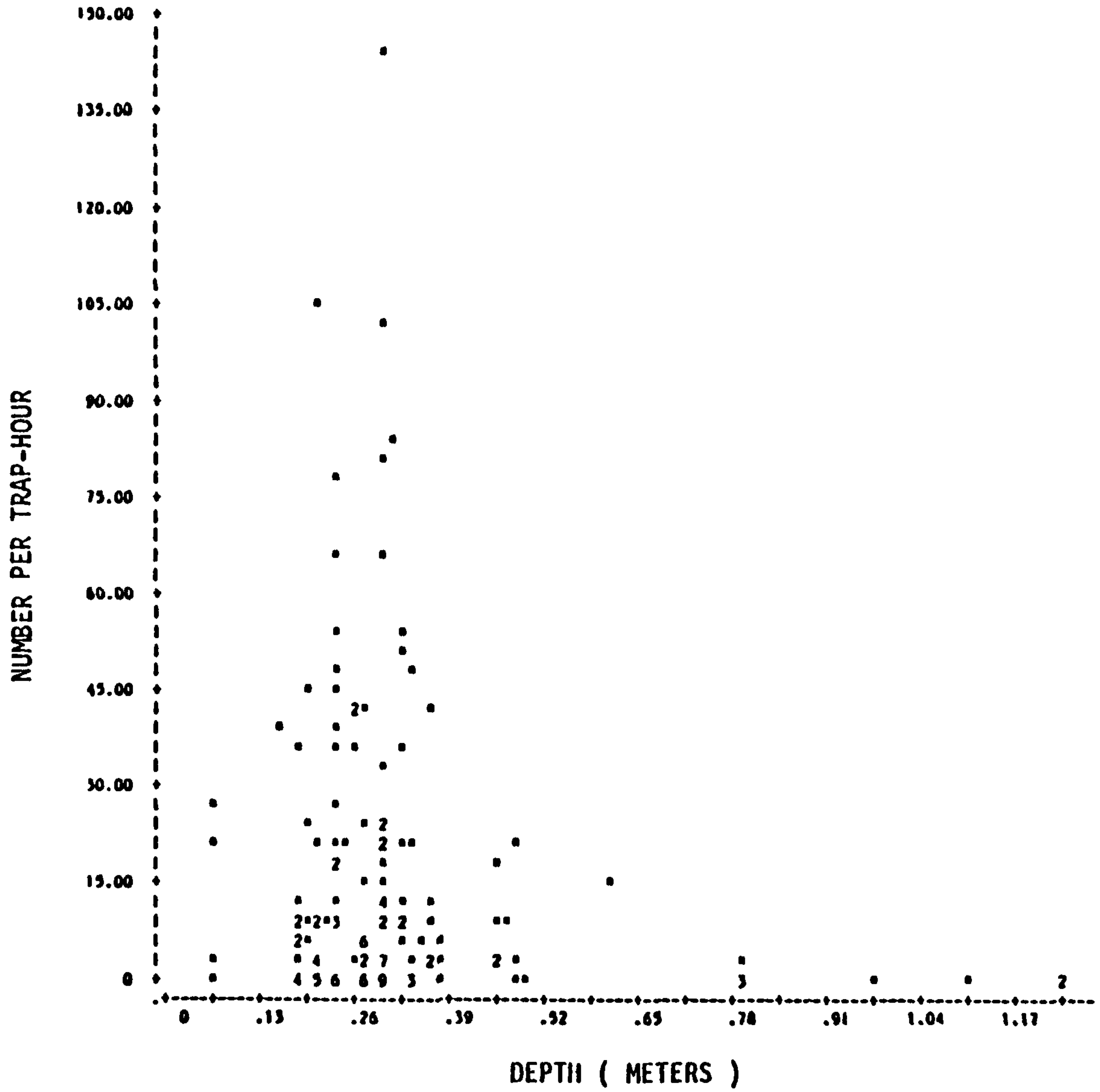


Fig. E-9. Response of Crenichthys nevadae to depth during July through September, 1980, at Lockes Ranch Spring.

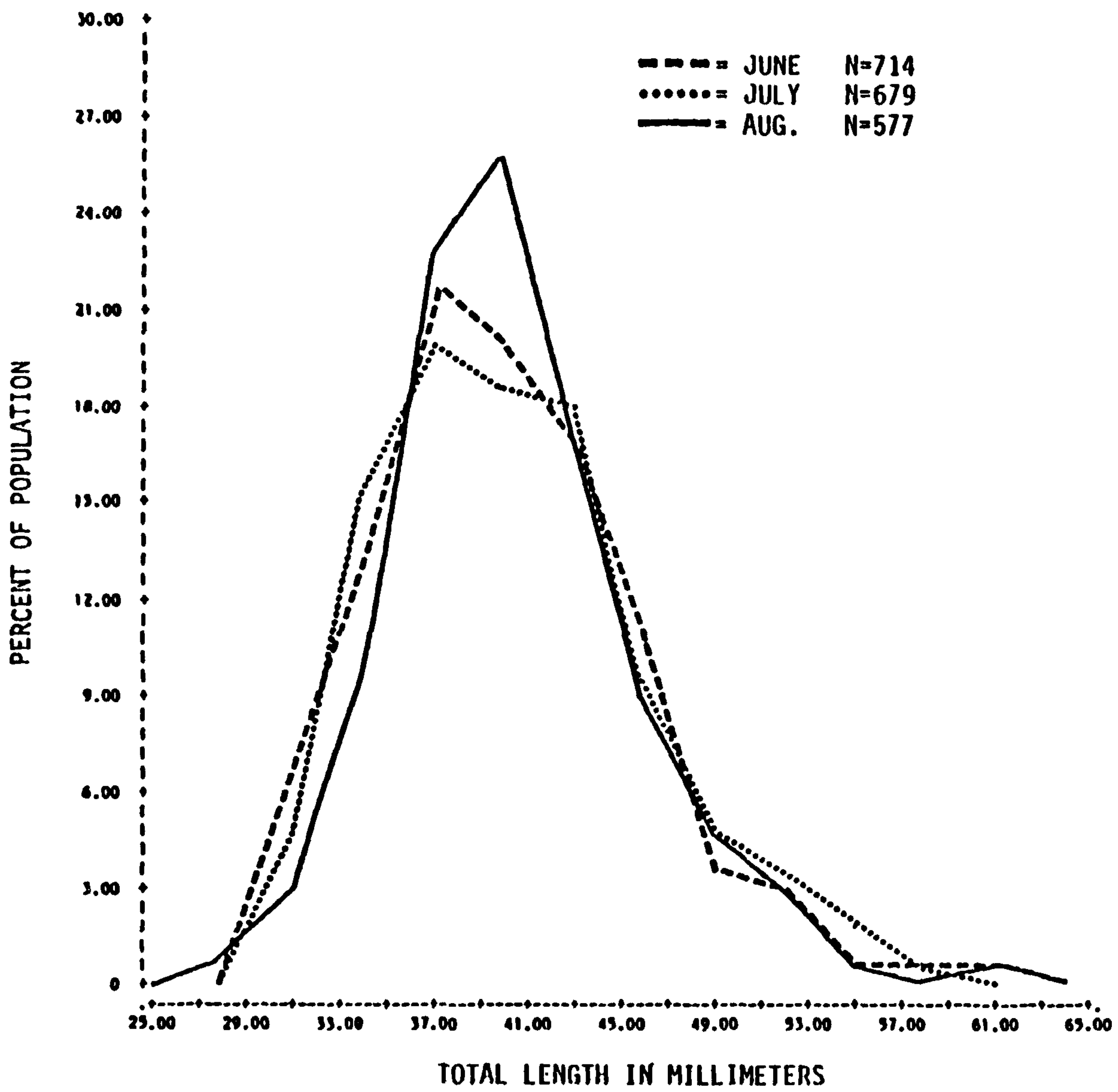


Fig. E-10. Population structure of Empitrichthys latos latos during June through August, 1980, at Shoshone North Pond.

Appendix F

Tables and Figures associated with food availability and food preference patterns for all species studied at each particular sample site.

Table F-1. Results of food habits from 11 intestines of *Rhinichthys osculus* collected from Preston Big Spring during June, 1980. Mean total length (TL) of fish examined = 49.2 mm.

Food	% Frequency of Occurrence	Mean Number per Occurrence	Mean % Volume	RI
Algae				
Filamentous algae	72.7		14	18
Diatoms	45.5		8	11
Ephemeroptera				
Unidentified larvae	9.1	0.3	8	3
Unidentified adult	9.1	0.2	<1	2
Odonata				
Zygopter				
Coenagrionidae larvae	9.1	0.1	1	2
Anisoptera larvae	9.1	0.1	<1	2
Trichoptera				
Hydroptilidae				
Oxyethira larvae	63.6	9.0	29	19
Hydroptila adult	45.5	1.6	6	11
Unidentified adult	18.2	0.5	14	6
Diptera				
Chironomidae larvae	54.5	2.5	4	12
Unidentified adult	9.1	0.1	<1	2
Insect eggs	9.1		1	2
Other Insecta	9.1	0.1	2	2
Acarina				
Hydrozetes	9.1	0.1	<1	2
Libertia	9.1	0.1	<1	2
Gastropoda				
Ancylidae	9.1	0.1	<1	2
Amphipod	9.1	0.2	<1	2
Detritus				
Gravel	9.1		2	
Debris	63.6		10	

Table F-2. Results of food habits from 10 intestines of Rhinichthys osculus collected from Preston Big Spring during July, 1980. Mean total length (TL) of fish examined = 42.3 mm.

Food	% Frequency Of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	50		7	14
Diatoms	10		< 1	2
Macrophyte	10		< 1	2
Plant seed	20		3	6
Amorphous plant material	10		4	3
Odonata				
Coenagrionidae	10	0.1	5	4
Trichoptera				
Hydroptilidae				
Oxyethira larvae	90	22.2	41	32
Unidentified pupae	10	0.1	1	3
Diptera				
Chironomidae larvae	30	1.4	6	9
Unidentified aquatic insects	30		12	10
Gastropoda				
Fluminicula operculum	20	0.2	2	6
Copepod	10	0.1	< 0.1	3
Fish scales	20	0.8	3	6
Detritus				
Gravel	10		5	
Debris	60		10	

Table F-3. Results of Food habits from 10 intestines of *Rhinichthys osculus* collected from Preston Big Spring during August, 1980. Mean total length (TL) of fish examined = 37.7 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	40		7	14
Diatoms	20		2	6
Plant seed	20		4	7
Amorphous plant material	10		1	3
Hemiptera				
Veliidae	10	0.2	2	3
Trichoptera				
Unidentified pupae	10	0.1	1	3
Coleoptera				
Staphylinidae adult	10	0.1	1	3
Unidentified larvae	10	0.1	< 1	3
Diptera				
Chironomidae larvae	30	0.4	6	10
Unidentified adult	10	0.1	3	4
Unidentified aquatic insects	50		24	21
Unidentified terrestrial insects	10		< 1	3
Acarina				
Hydrozetes	30	0.6	8	11
Gastropoda				
Fluminicula operculum	20	0.3	9	8
Detritus				
Gravel	10		4	
Debris	60		28	

Table F-4. Monthly selectivity of certain animal foods by fishes in Preston Big Spring during 1980. Foods for which indexes are reported represent major components of intestine and/or habitat samples.

Species	Food	Electivity Index				Linear Index			
		June	July	Aug	Sept	June	July	Aug	Sept
Crenichthys baileyi	Chironomidae[1]	0.08	0.36	0.69	-1.00	0.01	0.31	0.09	-0.01
	Hydroptilidae[2]	0.64	-0.26	0.89	-0.13	0.69	-0.09	0.82	-0.06
	Oligochaeta	-1.00	-1.00	-1.00	n.d.	-0.04	-0.07	-0.01	n.d.
	Hyalella[3]	-1.00	-1.00	-1.00	-0.20	-0.14	-0.06	-0.02	-0.10
	Odonata	n.d.[4]	-1.00	n.d.	-1.00	n.d.	-0.06	n.d.	-0.17
	Ephemeroptera	n.d.	-1.00	-1.00	0.00	n.d.	-0.04	-0.01	0.00
Rhinichthys osculus	Chironomidae	0.48	-0.65	1.00	0.89	0.11	-0.22	0.21	0.17
	Hydroptilidae	0.58	0.60	-1.00	-0.18	0.52	0.67	-0.05	-0.08
	Oligochaeta	-1.00	-1.00	-1.00	n.d.	-0.04	-0.07	-0.01	n.d.
	Hyalella	-0.87	-1.00	-1.00	-1.00	-0.13	-0.06	-0.02	-0.30
	Odonata	n.d.	-1.00	n.d.	-0.62	n.d.	-0.06	n.d.	-0.13
	Ephemeroptera	n.d.	-1.00	-1.00	0.00	n.d.	-0.04	-0.01	0.00

Continued

Table F-4. (cont.)

Species	Food	Electivity Index				Linear Index			
		June	July	Aug	Sept	June	July	Aug	Sept
Catostomus clarki	Chironomidae	-1.00	-1.00	n.d.	n.d.	-0.06	-0.28	n.d.	n.d.
	Hydroptilidae	-1.00	-1.00	n.d.	n.d.	-0.19	-0.22	n.d.	n.d.
	Oligochaeta	-1.00	-1.00	n.d.	n.d.	-0.04	-0.07	n.d.	n.d.
	Hyalella	-1.00	-1.00	n.d.	n.d.	-0.14	-0.06	n.d.	n.d.
	Odonata	n.d.	-1.00	n.d.	n.d.	n.d.	-0.06	n.d.	n.d.
	Ephemeroptera	n.d.	-1.00	n.d.	n.d.	n.d.	-0.04	n.d.	n.d.

[1]Chironomidae includes: *Cricotopus*, *Microtendipes*, *Microspectra*, *Eukefferiellia*, *Heterotirssocladius*, *Pentaneura*, *Ablabesmyia*, *Corynoneura*, *Pseudochironomus*, *Phoenopsectra*, *Paratanytarsus*

[2]Hydroptilidae includes: *Oxyethira*, *Stactobiella*, *Hydroptila*, *Leucotrichia*

[3]Amphipoda

[4]no data

Table F-5. Results of food habits from 10 intestines of Rhinichthys osculus collected from Preston Big Spring during September, 1980. Mean total length (TL) of fish examined = 37.0 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	60		17	16
Diatoms	90		41	27
Plant seed	10		1	2
Collembola	10	0.3	2	2
Odonata				
Coenagrionidae	10	0.2	1	2
Thysanoptera	10	0.1	<1	2
Trichoptera				
Hydroptilidae				
Oxyethira larvae	30	1.0	5	7
Unidentified larvae	10	0.1	1	2
Diptera				
Chironomidae larvae	30	1.0	1	6
Unidentified adult	10	0.1	4	3
Unidentified aquatic insects	10		1	2
Acarina				
Hydrozetes	60	1.8	4	13
Gastropoda				
Unidentified snail	10	0.1	< 1	2
Fluminicula operculum	20	0.3	2	5
Cladocera	10	0.3	< 1	2
Copepod	10	0.1	<0.1	2
Ostracod	20	0.3	1	4
Detritus				
Gravel	20		1	
Debris	100		16	

Table F-6. Results of food habits from 11 intestines of *Crenichthys baileyi* collected from Preston Big Spring during June, 1980. Mean total length (TL) of fish examined = 43.4 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	63.6		24	32
Diatoms	27.3		5	12
Aquatic macrophyte	27.3		5	12
Plant seed	18.2		4	8
Trichoptera				
Hydroptilidae				
Oxyethira larvae	18.2	4.6	9	10
Hydroptila adult	18.2	0.2	6	9
Coleoptera adult	9.1	0.1	3	4
Diptera				
Chironomidae larvae	18.2	0.4	2	7
Acarina				
Hydrozetes	9.1	0.1	1	4
Libertia	9.1	0.1	<1	3
Detritus				
Gravel	27.3		2	
Debris	90.9		41	

Table F-7. Results of food habits from 10 intestines of *Crenichthys baileyi* collected from Preston Big Spring during July, 1980. Mean total length (TL) of fish examined = 38.2 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	100		48	42
Diatoms	30		6	10
Higher plant	20		4	7
Trichoptera				
Hydroptilidae				
Oxyethira larvae	30	0.3	3	9
Oxyethira pupae	10	0.2	2	3
Coleoptera adult	20	0.2	3	7
Diptera				
Chironomidae larvae	20	2.3	6	7
Acarina	10	0.1	<1	3
Ostracod	10	0.1	<1	3
Snail operculum	10	0.3	<1	3
Fish scale	20	0.4	1	6
Detritus				
Gravel	10		1	
Debris	90		25	

Table F-8. Results of food habits from 10 intestines of *Crenichthys baileyi* collected from Preston Big Spring during August, 1980. Mean total length (TL) of fish examined = 32.7 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	60		21	23
Diatoms	70		24	27
Higher plant	50		12	18
Trichoptera				
Hydroptilidae				
Oxyethira	10	3.3	9	6
Diptera				
Chironomidae larvae	20	0.4	7	8
Insecta eggs	50		3	15
Ostracod	10	0.1	1	3
Detritus	80		23	

Table F-9. Results of food habits from 10 intestines of *Crenichthys baileyi* collected from Preston Big Spring during September, 1980. Mean total length (TL) of fish examined = 41.6 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	90		20	36
Diatoms	10		2	4
Higher plant	20		10	10
Amorphous plant	60		26	28
Trichoptera				
Hydroptilidae				
Oxyethira	10	0.1	2	4
Insect egg	20		3	8
Acarina	20	0.3	<1	7
Amphipod	10	0.1	<0.1	3
Detritus				
Gravel	30		6	
Debris	80		32	

Table F-10. Results of food habits from 10 intestines of <u>Catostomus clarki</u> sampled from Preston Big Spring, during June, 1980. Mean total length (TL) of fish sampled = 174.2 mm.

Food*	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Filamentous Algae	25.0		10	16
Amorphous Plant Material	100.00		89	84
Detritus	12.8		1	

*Two fish sampled had empty intestines

Table F-11. Results of food habits from 10 intestines of <u>Catostomus clarki</u> sampled from Preston Big Spring during July, 1980. Mean total length (TL) of fish sampled = 205.0 mm.

Food	% Frequency of Occurrence	Mean Number Per Intestine	Mean % Volume	RI
Filamentous algae	10		2	4
Diatoms	80		21	35
Higher Plant	10		2	4
Amorphous Plant Material	100		64	57
Detritus				
Gravel	20		2	
Debris	20		11	

Table F-12. Results of food habits from 8 intestines of *Crenichthys nevadae* collected from Big Spring at Lockes Ranch during June, 1980. Mean total length (TL) of fish examined = 45.7 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	62.5		20	23
Macrophyte				
Aquatic	12.5		1	4
Terrestrial	25.0		3	8
Plant seed	12.5		1	4
Gastropoda	62.5	12.8	54	32
Amphipod	12.5	0.1	1	4
Ostracod	50.0	3.1	5	15
Fish scale	37.5		4	11
Detritus	62.5		10	

Table F-13. Monthly selectivity of certain animal foods by fishes in Big Spring, Lockes Ranch during 1980. Foods for which indexes are reported represent major components of intestine and/or habitat samples.

Species	Food	Electivity Index				Linear Index			
		June	July	Aug	Sept	June	July	Aug	Sept
Crenichthys nevadae	Chironomidae[1]	-1.00	-0.83	-0.14	-0.43	-0.04	-0.10	-0.02	-0.03
	Oligochaeta	-1.00	-1.00	0.00	0.00	-0.47	-0.56	0.00	0.00
	Ostracoda	0.78	0.98	1.00	1.00	0.14	0.98	0.90	0.88
	Gastropoda	0.34	n.d.[2]	-1.00	n.d.	0.34	n.d.	-0.85	n.d.

[1] Chironomidae includes: Cricotopus, Paratendipes

[2] no data

Table F-14. Results of food habits from 10 intestines of <u>Crenichthys nevadae</u> collected from Big Spring at Lockes Ranch during July, 1980. Mean total length (TL) of fish examined = 23.2 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	10		4	4
Amorphous plant material	20		1	7
Diptera				
Chironomidae larvae	50	2.6	3	16
Acarina	30	1.4	<1	9
Gastropoda	10	0.7	2	4
Ostracod	100	401.8	83	57
Fish scale	10	0.1	<1	3
Detritus	30		8	

Table F-15. Results of food habits from 10 intestines of Crenichthys nevadae collected from Big Spring at Lockes Ranch during August, 1980. Mean total length (TL) of fish examined = 24.7 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	50		9	16
Higner plant	10		<1	3
Hemiptera adult	10	0.1	2	3
Diptera				
Chironomidae larvae	70	2.2	9	21
Acarina	30	0.3	2	9
Emphipod	30	0.8	12	11
Ostracod	90	30.8	43	36
Detritus	80		23	

Table F-16. Results of food habits from 10 intestines of <u>Crenichthys nevadae</u> collected from Big Spring at Lockes Ranch during September, 1980. Mean total length (TL) of fish examined = 30.9 mm.

Food	% Frequency Of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Filamentous algae	60		5	18
Ephemeroptera				
Unidentified larvae	10	0.1	10	6
Diptera				
Chrionomidae larvae	40	1.2	3	12
Acarina	20	1.0	1	6
Gastropoda				
Hydrobiidae	50	4.0	18	19
Amphipod	10	0.1	4	4
Ostracod	80	70.3	26	29
Fish sclae	20	3.3	3	6
Detritus	70		30	

Table F-17. Results of food habits from 120 intestines of *Empetrichthys latos* from Manse Spring, Nevada during 1961-1963. Mean standard length (SL) = 42.6 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Plant	5.0		2	4
Ephemeroptera				
Baetidae	5.0	1.7	2	4
Unidentified	2.5	0.5	3	6
Coleoptera	6.6	0.4	1	5
Insecta larvae	15.0	1.5	8	14
Other Insecta	9.1	0.1	1	6
Insecta parts	38.3	1.1	11	30
Gastropoda				
Hydrobioid	5.0	0.3	<1	3
Physa	5.0	0.6	1	4
Unidentified	14.1	1.1	3	11
Cladocera	3.3	4.0	<1	2
Ostracod	3.3	0.2	<1	2
Eggs	11.1	0.2	3	9
Detritus				
Sand	35.8		9	
Debris	78.3		56	
Other matter	9.5		1	

Table F-18. Results of food habits from 10 intestines of *Rhinichthys osculus* collected from Ash Spring during June, 1980. Mean total length (TL) of fish examined = 37.5 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	60		2	17
Ephemeroptera				
Baetidae				
Tricorythodes	10	0.1	7	5
Unidentified genera	10	0.1	1	3
Homoptera	10	0.2	3	4
Trichoptera				
Unidentified pupae	10	0.1	8	5
Hymenoptera	10	0.1	1	3
Coleoptera				
Unidentified adult	10	0.1	1	3
Diptera				
Chironomid larvae	100	35.0	46	41
Chironomid pupae	10	0.1	2	3
Chironomid adult	10	0.1	<1	3
Unidentified adult	10	0.3	4	4
Other Insecta	10	0.1	<1	3
Ostracod	20	0.2	1	6
Detritus	100		24	

Table F-19. Results of food habits from 10 intestines of *Rhinichthys osculus* collected from Ash Spring during July, 1980. Mean total lenth (TL) of fish examined = 37.4 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	70		2	13
Compsopogon	10		7	3
Amorphous plant material	30		3	6
Ephemeroptera				
Baetidae	10	0.1	1	2
Trichoptera				
Hydroptilidae				
Oxyethira	20	0.2	<1	4
Unidentified genera	70	2.2	5	14
Diptera				
Chironomid larvae	90	5.8	18	20
Unidentified adult	10	0.1	<1	2
Other Insecta				
1st instar larvae	30	21.0	3	6
Unidentified larvae	10	0.1	<1	2
Unidentified adult	50	0.6	30	14
Unidentified	20	0.2	2	4
Arachnidae	30	0.3	3	6
Unidentified animal material	20		3	4
Detritus	100		23	

Table F-20. Results of food habits from 10 intestines of *Rhinichthys osculus* collected from Ash Spring during August, 1980. Mean total length (TL) of fish examined = 34.7 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	40		2	12
Oedogonium	10		1	3
Amorphous plant material	10		1	3
Trichoptera				
Hydroptilidae				
Oxyethira	10	0.1	6	5
Unidentified genera	100	4.5	34	38
Diptera				
Chironomidae larvae	50	1.3	8	16
Unidentified pupae	20	0.2	6	7
Other Insecta				
Unidentified adult	20		1	6
Unidentified animal material	20		18	11
Detritus	100		23	

Table F-21. Monthly selectivity of certain animal foods by fishes in Ash Spring during 1980. Foods for which indexes are reported represent major components of intestine and/or habitat samples.

Species	Food	Electivity Index				Linear Index			
		June	July	Aug	Sept	June	July	Aug	Sept
Cichlasoma nigrofasciatum	Chironomidae[1]	0.87	0.50	1.00	0.12	0.79	0.44	0.56	0.80
	Hydroptilidae[2]	1.00	0.49	1.00	0.71	0.13	0.19	0.39	0.39
	Melanoides[3]	-1.00	n.d.[4]	-1.00	n.d.	-0.91	n.d.	-0.94	n.d.
Rhinichthys osculus	Chironomidae	0.88	-0.07	1.00	n.d.	0.90	-0.03	0.21	n.d.
	Hydroptilidae	0.00	-0.11	1.00	n.d.	0.00	-0.02	0.73	n.d.
	Melanoides	-1.00	n.d.	-1.00	n.d.	-0.91	n.d.	-0.94	n.d.
Poecilia mexicana	Chironomidae	-1.00	-1.00	0.00	-1.00	-0.06	-0.22	0.00	-0.28
	Hydroptilidae	0.00	-1.00	0.00	-1.00	0.00	-0.10	0.00	-0.08
	Melanoides	-1.00	n.d.	-1.00	n.d.	-0.91	n.d.	-0.94	n.d.

[1]Chironomidae includes: *Chironomus*, *Cryptochironomus*, *Cricotopus*, *Polypedilum*, *Midcrotendipes*, *Dicrotendipes*

[2]Hydtoptilidae includes: *Oxyethira*

[3]Gastropoda

[4]no data

Table F-22. Results of food habits from 11 intestines of *Gambusia affinis* collected from the outflow of Ash Spring during September, 1980. Mean total length (TL) of fish examined = 30.0 mm.

Food	% Frequency of Occurrence	Mean Number per Occurrence	Mean % Volume	RI
Collembola	9.1	0.7	4	4
Trichoptera				
Hydroptilidae				
Oxyethira	9.1	0.1	<1	3
Diptera				
Chironomid adult	27.3	0.4	16	15
Unidentified adult	18.1	0.2	5	8
Hymenoptera				
Formicidae	9.1	0.1	7	6
Gastropoda				
Melanoides tuberculatus	9.1	0.1	1	3
Other Insecta	36.4	0.5	10	16
Unidentified insect larvae	9.1	27.3	3	4
Unidentified adult insect	64.0	1.8	49	39
Detritus	36.0		3	

Table F-23. Results of food habits from 10 intestines of *Poecilia mexicana* collected from the outflow of Ash Spring during June, 1980. Mean total length (TL) of fish sampled = 64.7 mm.

Food	% Frequency of Occurrence	Mean Number per Occurrence	Mean % Volume	RI
Algae				
Spirogyra	100		36	69
Compsopogon	60		1	31
Detritus	100		63	

Table F-24. Results of food habits from 10 intestines of *Poecilia mexicana* collected from the outflow of Ash Spring during July, 1980. Mean total length (TL) of fish sampled = 52.0 mm.

Food	% Frequency of Occurrence	Mean Number per Occurrence	Mean % Volume	RI
Algae				
Spirogyra	100		27	100
Detritus	100		73	

Table F-25. Results of food habits from 10 intestines of *Poecilia mexicana* collected from the outflow of Ash Spring during August, 1980. Mean total length (TL) of fish sampled = 40.6 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	100		15	44
Compsopogon	10		<1	4
Oedogonium	100		26	48
Unidentified filament	10		<1	4
Detritus	100		58	

Table F-26. Results of food habits from 10 intestines of *Poecilia mexicana* collected from the outflow of Ash Spring during September, 1980. Mean total length (TL) of fish sampled = 46.5 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	80		20	70
Lyngbya	10		1	8
Oedogonium	20		1	14
Unidentified filament	10		1	8
Detritus	100		77	

Table F-27. Results of food habits from 10 intestines of *Cichlasoma nigrofasciatum* from the outflow of Ash Spring during June, 1980. Mean total length (TL) of fish sampled = 36.0 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	90		1	19
Oedogonium	10		<1	2
Compsopogon	20		10	6
Amorphous plant material	10		9	4
Ephemeroptera				
Baetidae	30	0.3	1	4
Trichoptera				
Leptoceridae				
Nectopsyche	20	0.3	3	5
Hydroptilidae	80	9.0	8	18
Lepidoptera				
Pyralidae				
Parargyractis	10	0.1	4	3
Coleoptera				
Elmidae				
Microcylloepus	20	0.2	1	4
Diptera				
Chironomidae larvae	80	57.2	51	27
Chironomidae pupae	20	0.2	<1	4
Other Insecta	10	0.1	<1	2
Detritus	100		11	

Table F-28. Results of food habits from 10 intestines of *Cichlasoma nigrofasciatum* from the outflow of Ash Spring during July, 1980. Mean total length (TL) of fish sampled = 42.8 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	100		55	27
Compsopogon	20		<1	4
Amorphous plant material	70		4	13
Ephemeroptera				
Baetidae	20	0.2	<1	3
Trichoptera				
Leptoceridae				
Nectopsyche	20	0.3	1	4
Hydroptilidae				
Oxyethira	20	0.9	1	4
Unidentified genera	100	6.8	3	18
Coleoptera				
Elmidae				
Microcylloepus	30	0.8	1	5
Diptera				
Chironomidae larvae	100	17.8	11	19
Gastropoda	20	0.2	<1	3
Detritus	100		23	

Table F-29. Results of food habits from 10 intestines of *Cichlasoma nigrofasciatum* from the outflow of Ash Spring during August, 1980. Mean total length (TL) of fish sampled = 34.7 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	100		4	18
Compsopogon	10		8	3
Unidentified branched filament	10		<1	2
Amorphous plant material	10		1	2
Ephemeroptera				
Baetidae	50	1.1	2	9
Trichoptera				
Hydroptilidae				
Oxyethira	80	2.2	8	15
Unidentified genera	100	13.8	13	20
Unidentifed pupae	10	0.1	<1	2
Diptera				
Chironomid larvae	90	22.9	40	22
Unidentified larvae	10	0.3	<1	2
Unidentified pupae	10	0.1	<1	2
Unidentified adult	10	0.2	<1	2
Copepod	10	0.1	<1	2
Detritus	100		24	

Table F-30. Results of food habits from 10 intestines of *Cichlasoma nigrofasciatum* from the outflow of Ash Spring during September, 1980. Mean total length (TL) of fish sampled = 45.1 mm.

Food	% Frequency of Occurrence	Mean Number per Intestine	Mean % Volume	RI
Algae				
Spirogyra	50		23	16
Unidentified branched filament	60		6	14
Amorphous plant material	10		1	2
Collembola	10	0.1	< 1	2
Ephemeroptera				
Baetidae	10	0.1	1	2
Odonata				
Libellulidae	20	0.2	8	6
Trichoptera				
Hydroptilidae				
Oxyethira	50	3.0	12	13
Unidentified genera	60	6.2	6	14
Diptera				
Chironomid larvae	70	7.1	9	17
Ceratopogonidae	20	1.3	2	5
Unidentified larvae	10	0.1	1	2
Ostracod	20	1.4	1	5
Detritus	100		30	

Figure F- 1. Relative percent composition of major invertebrate community components by habitat types. Preston Big Spring, June, 1980. N = total density of organisms used in calculation of percentages.

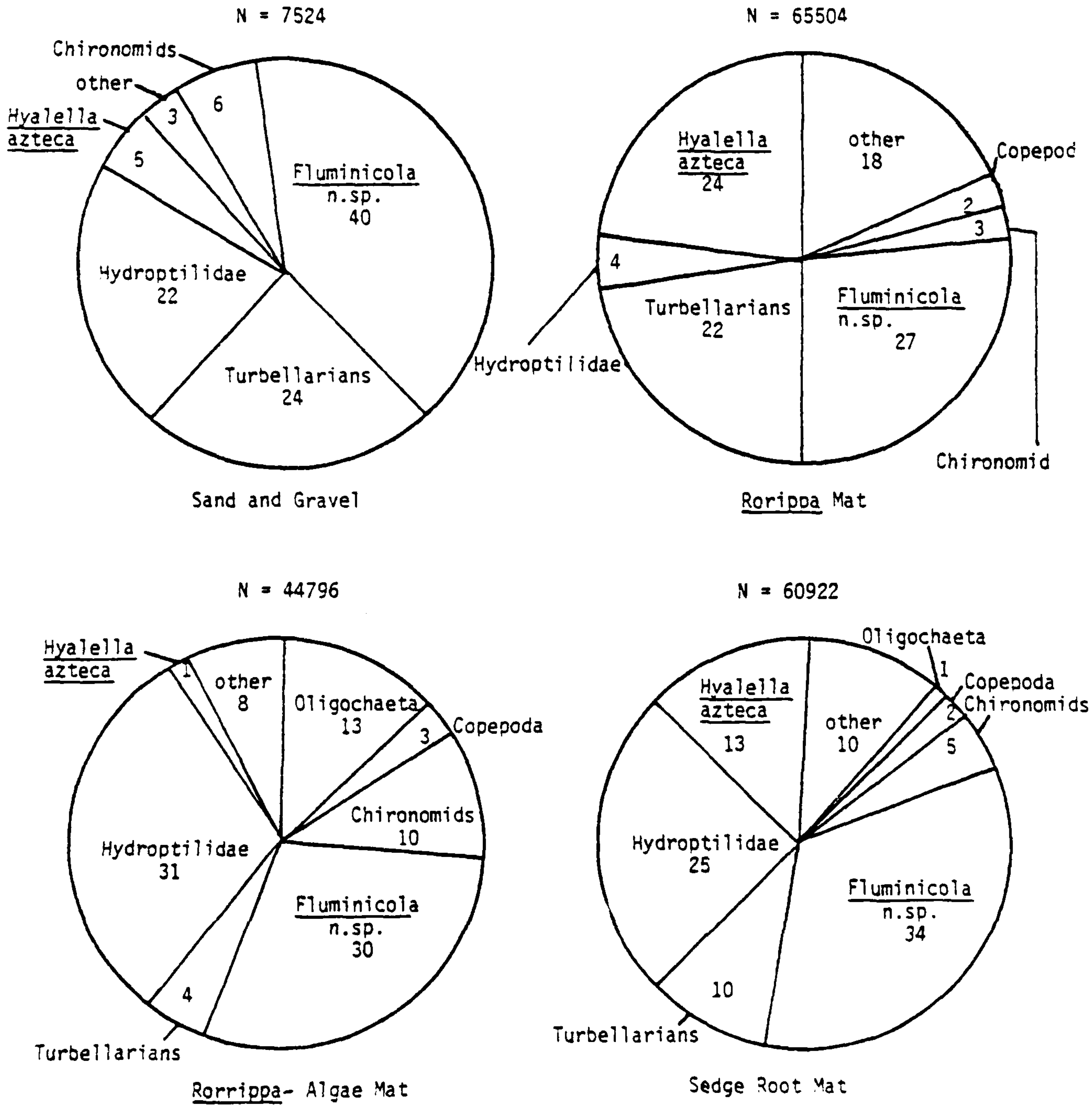


Figure F- 2. Relative percent composition of major invertebrate community components by habitat types. Preston Big Spring, July, 1980. N = total density of organisms used in calculation of percentages.

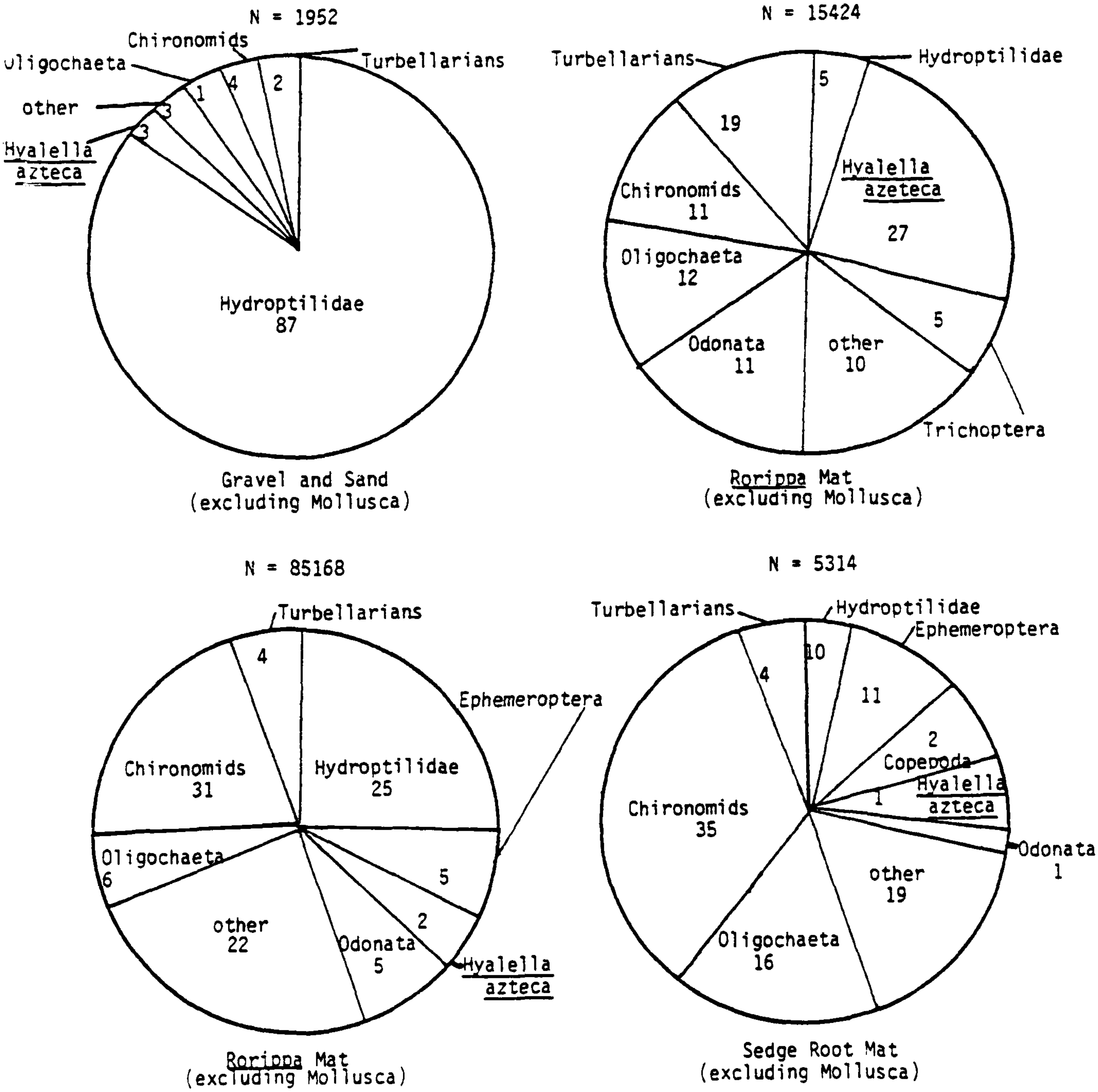


Figure F-3 . Relative percent composition of major invertebrate community components by habitat types. Preston Big Spring, August, 1980. N = total density of organisms used in calculation of percentages.

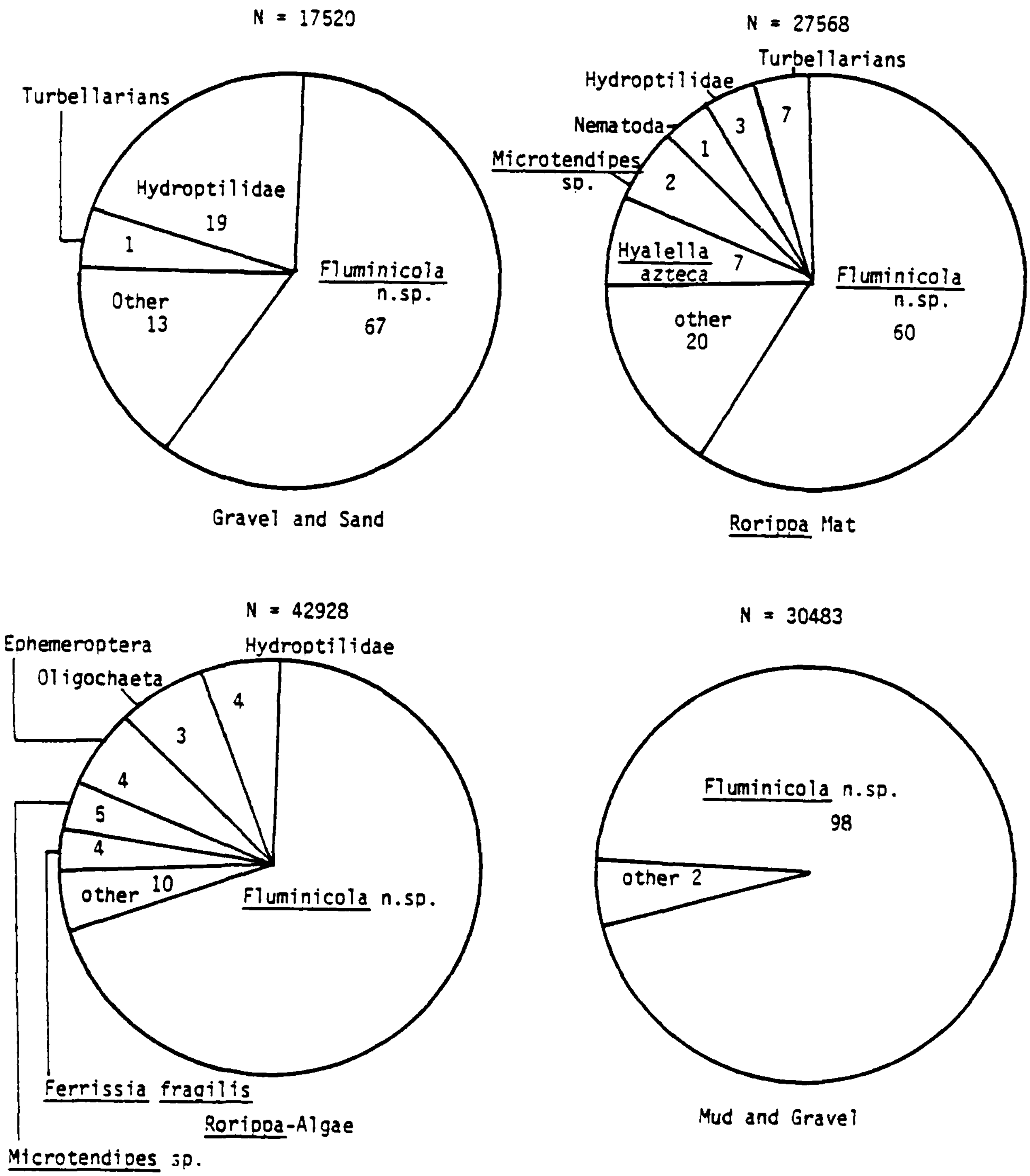


Figure F-4 . Relative percent composition of major invertebrate community components by habitat types. Preston Big Spring, September, 1980. N = total density of organisms used in calculation of percentages.

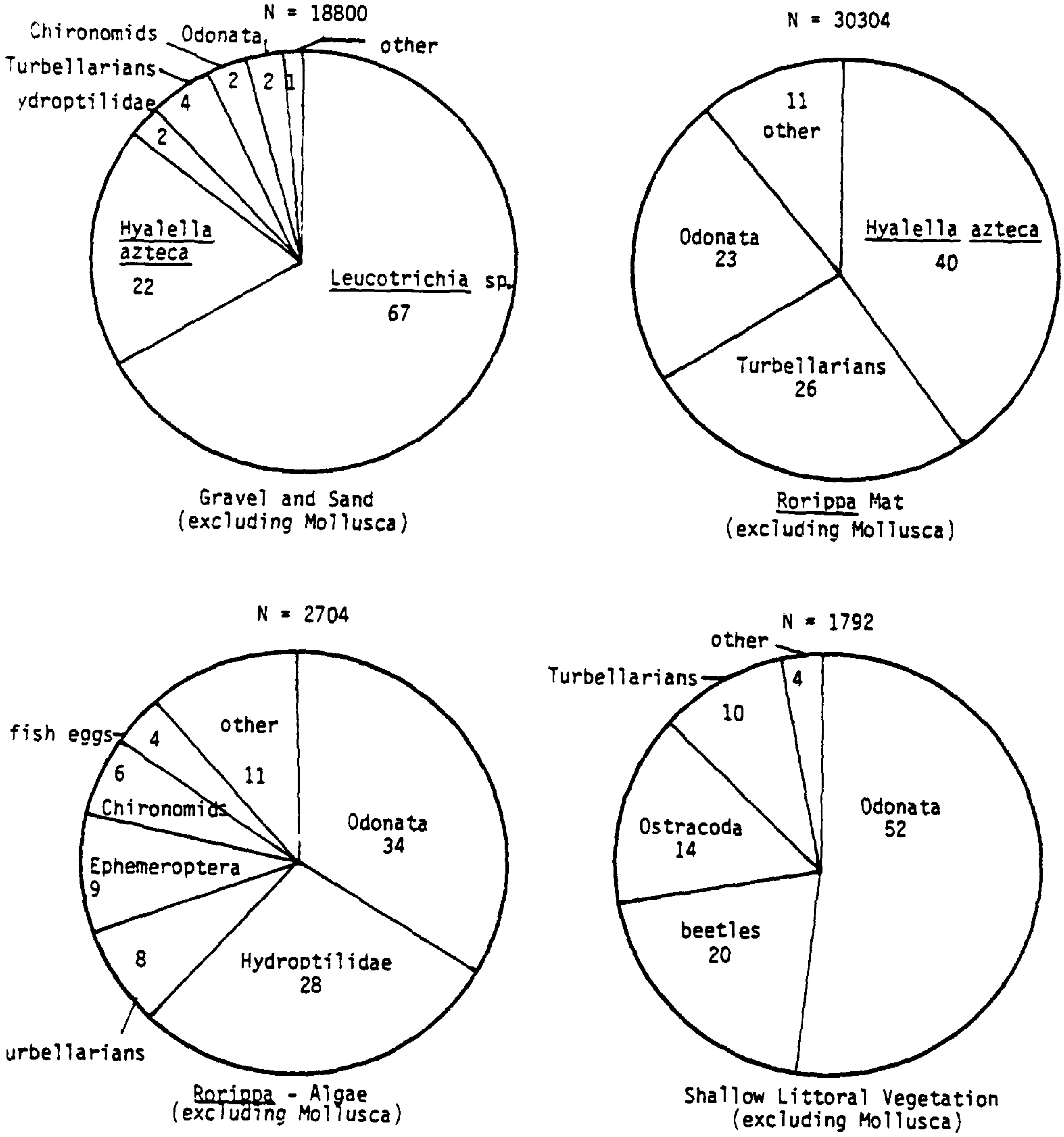


Figure F-5. Results of food habits for *Rhinichthys osculus* expressed as percentage volume of the total diet. Preston Big Spring, Nevada, June, 1980. N = 11.

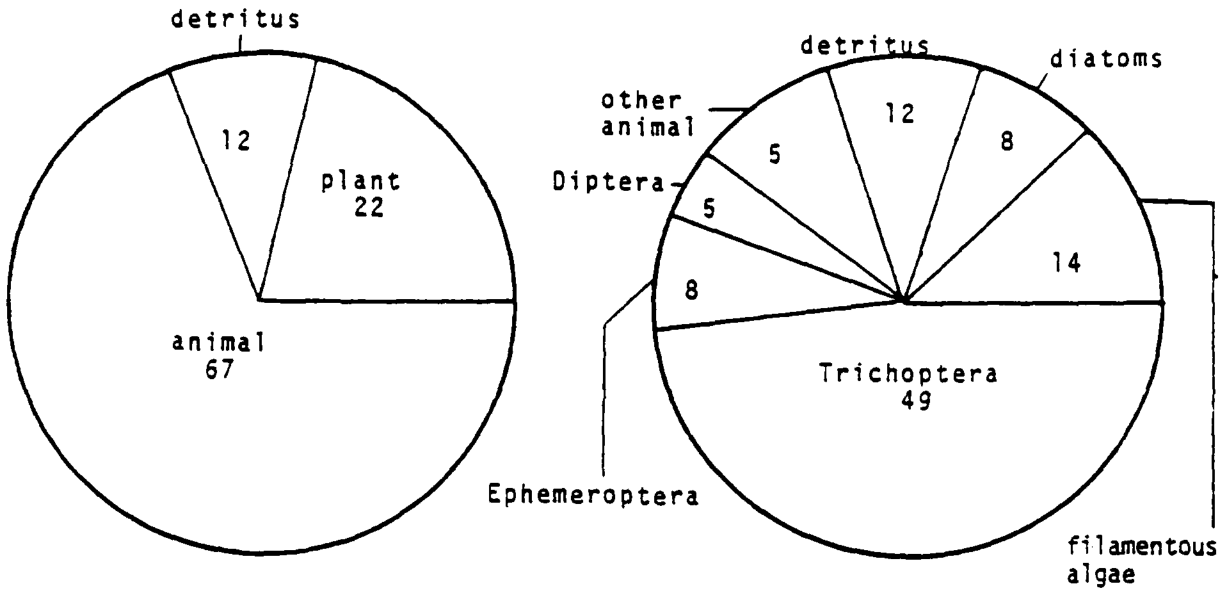


Figure F-6. Results of food habits for *Rhinichthys osculus* expressed as percentage volume of the total diet. Preston Big Spring, Nevada, July, 1980. N = 10.

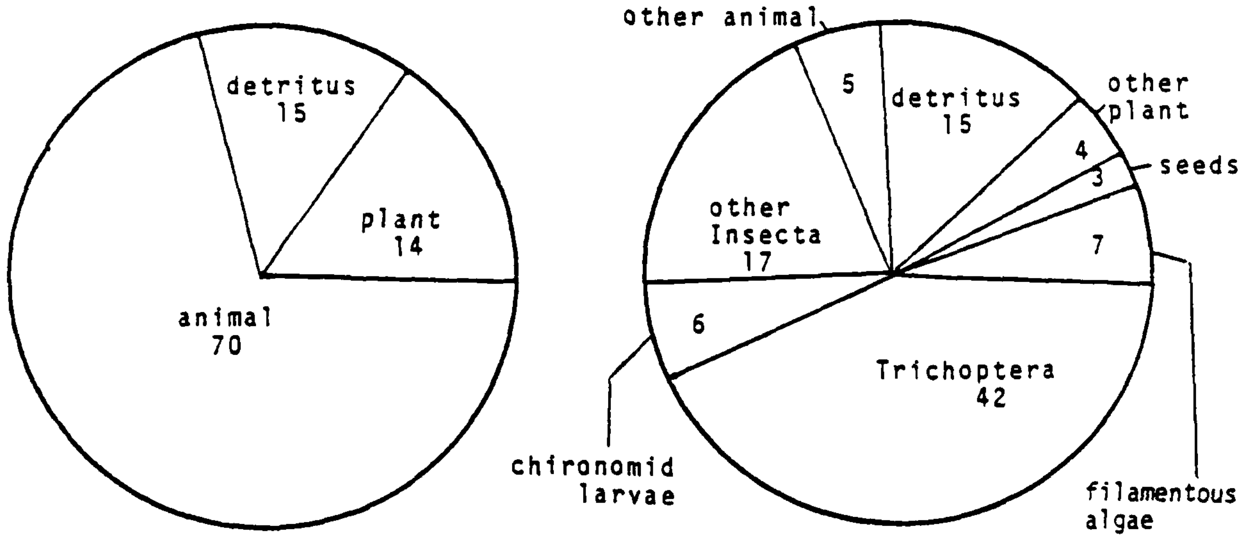


Figure F-7. Results of food habits for *Rhinichthys osculus* expressed as percentage volume of the total diet. Preston Big Spring, Nevada, August, 1980. N = 10.

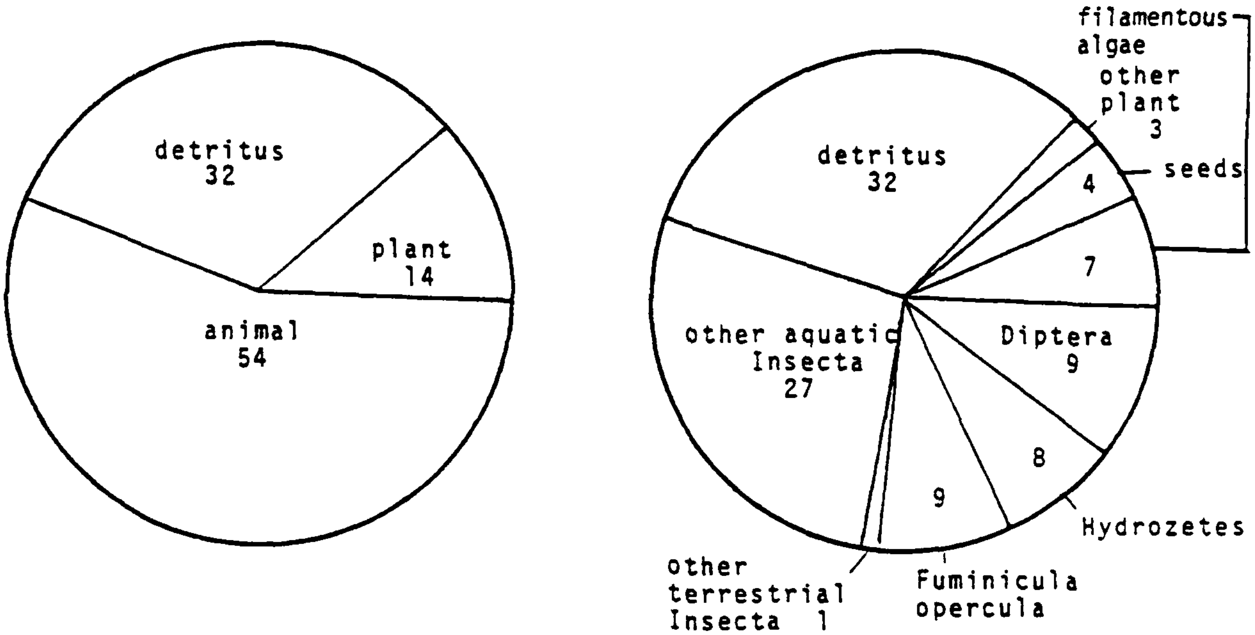


Figure F-8. Results of food habits for *Rhinichthys osculus* expressed as percentage volume of the total diet. Preston Big Spring, Nevada, September, 1980. N = 10.

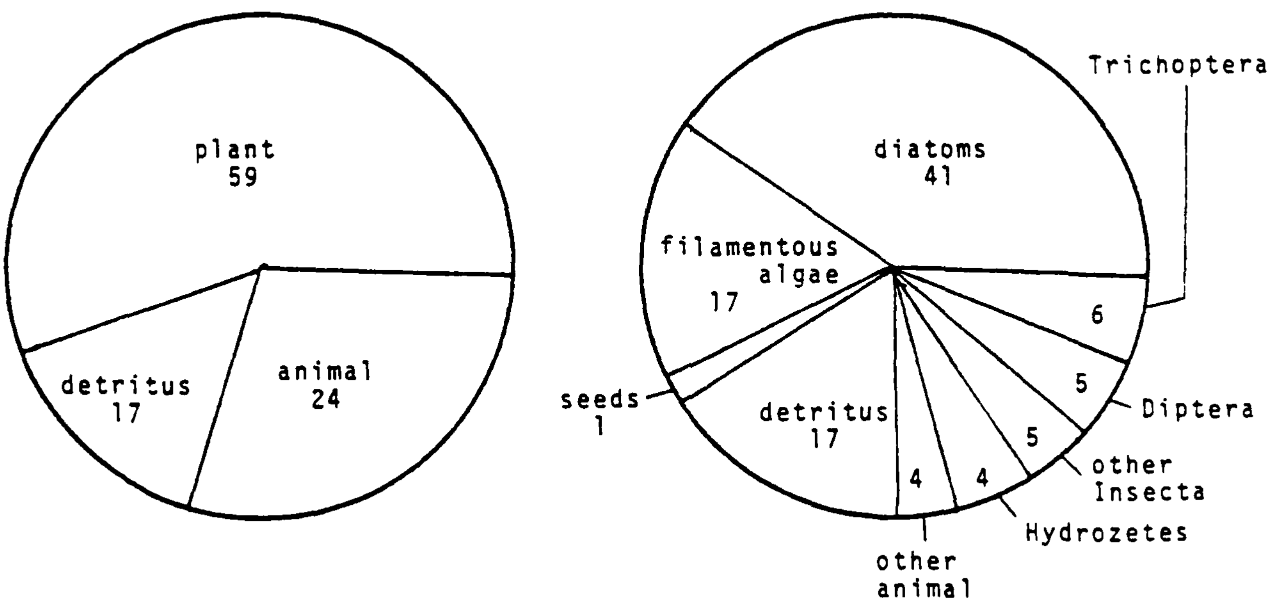


Figure F-9. Results of food habits for Crenichthys baileyi expressed as percentage volume of the total diet. Preston Big Spring, Nevada, June, 1980. N = 11.

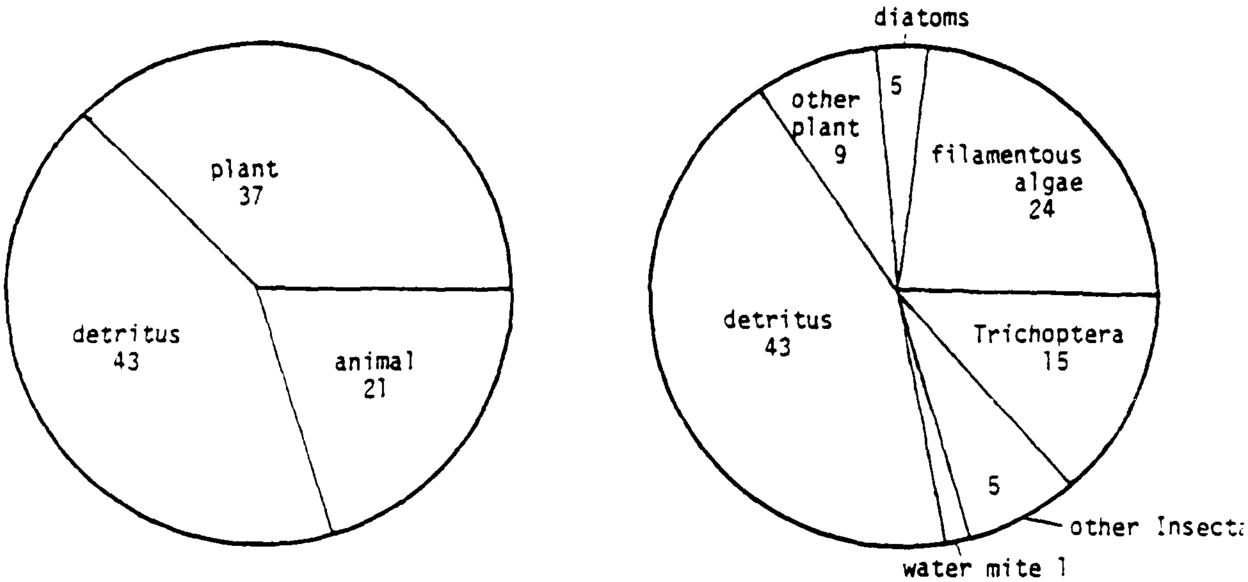


Figure F-10. Results of food habits for Crenichthys baileyi expressed as percentage volume of the total diet. Preston Big Spring, Nevada, July, 1980. N = 10.

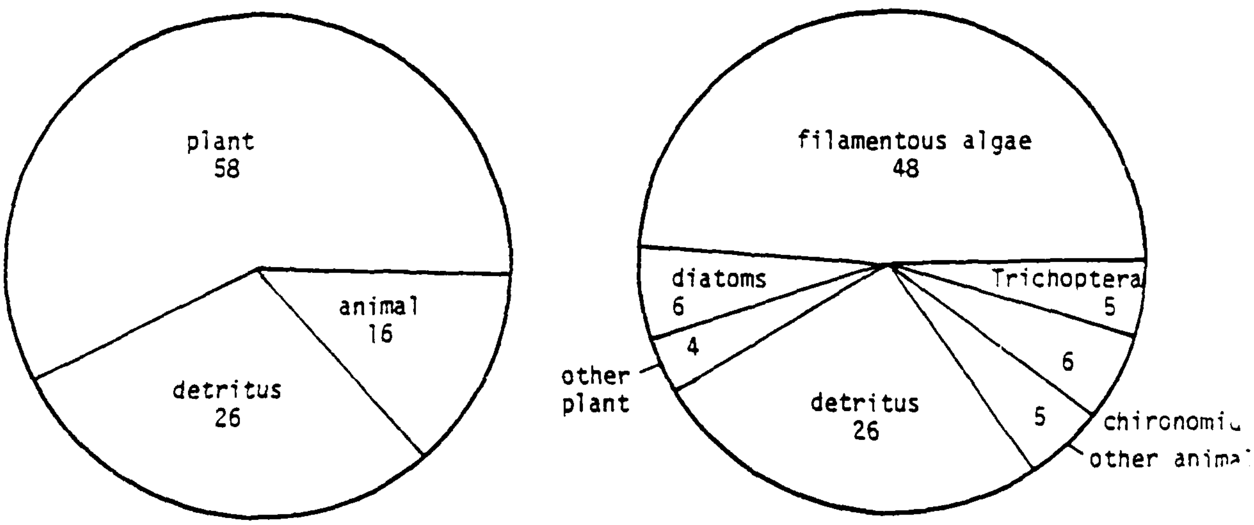


Figure F-11 . Results of food habits for Crenichthys baileyi expressed as percentage volume of the total diet. Preston Big Spring, Nevada, August, 1980. N = 10.

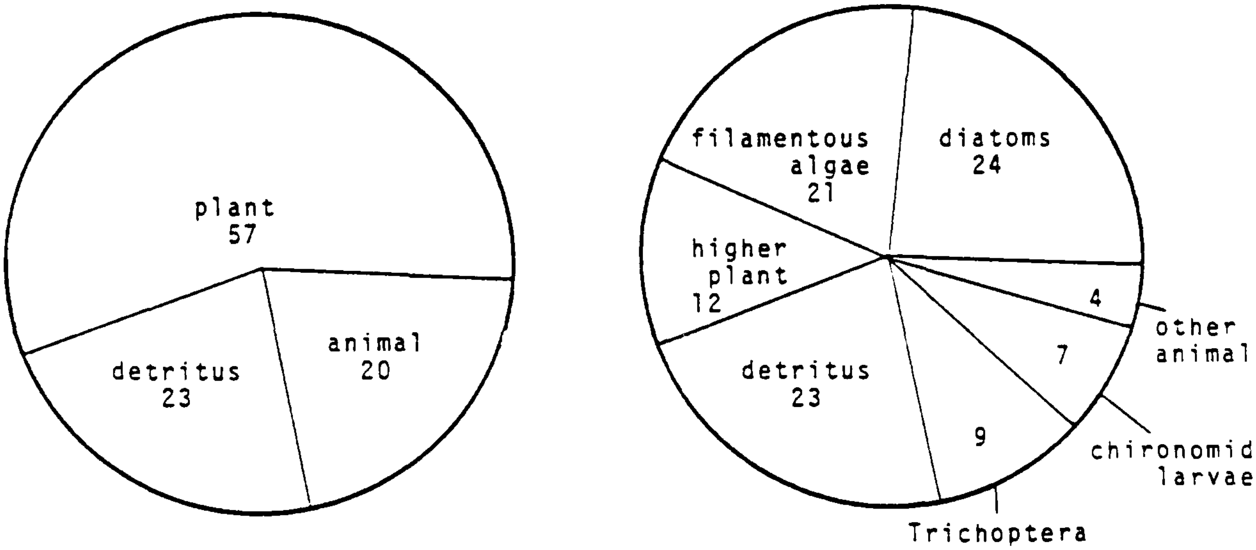


Figure F-12 . Results of food habits for Crenichthys baileyi expressed as percentage volume of the total diet. Preston Big Spring, Nevada, September, 1980. N = 10.

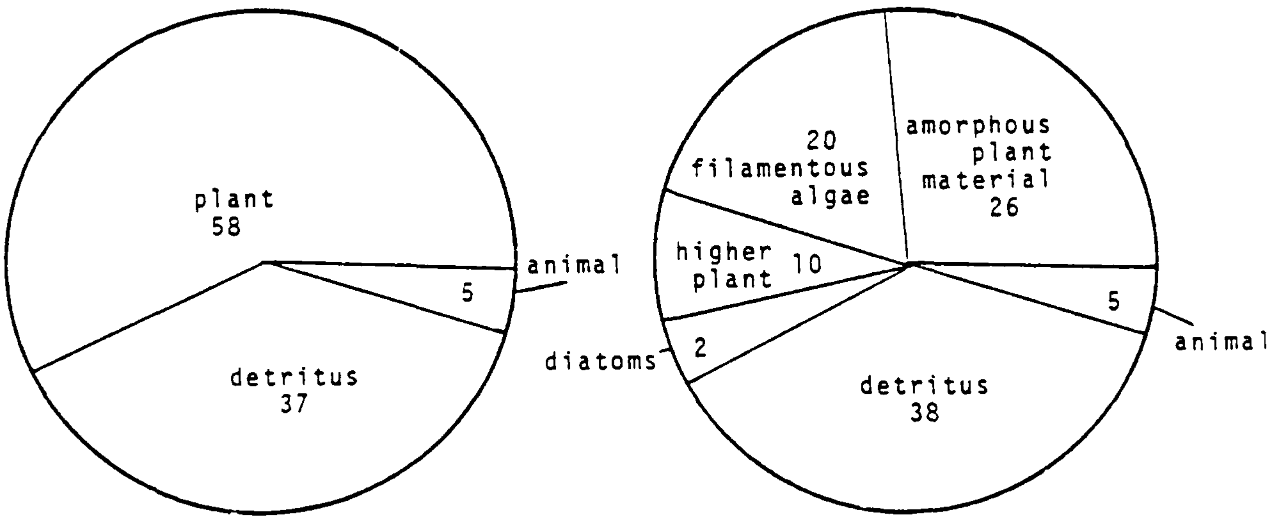
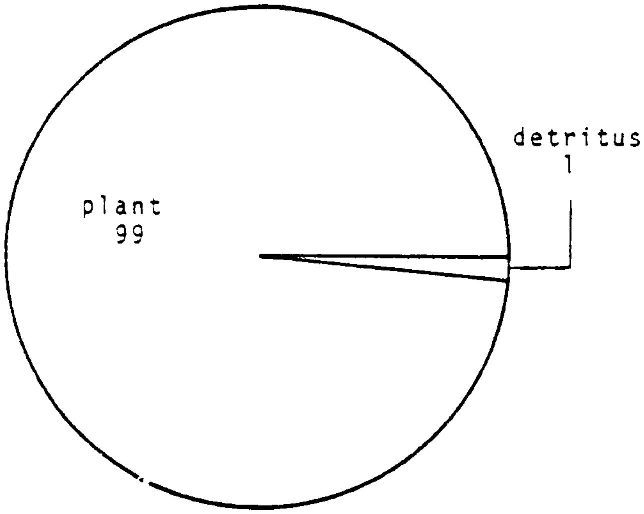


Figure F-13. Results of food habits for Catostomus clarki expressed as percentage volume of the total diet. Preston Big Spring, Nevada, June, 1980. N = 10.



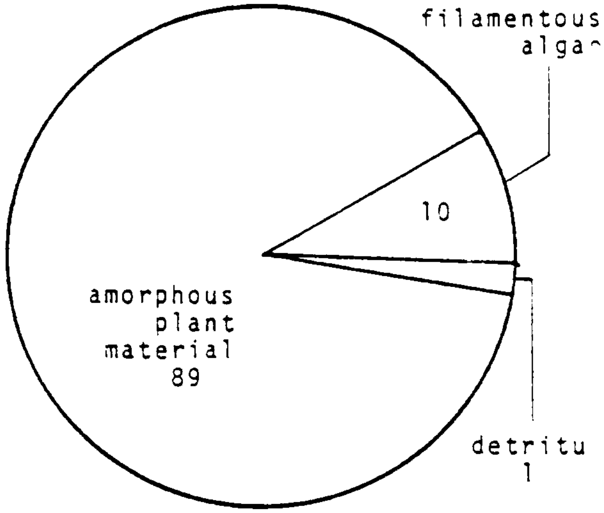
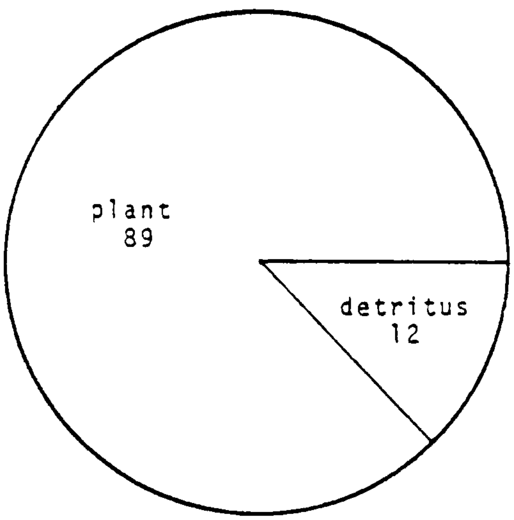


Figure F-14. Results of food habits for Catostomus clarki expressed as percentage volume of the total diet. Preston Big Spring, Nevada, July, 1980. N = 10.



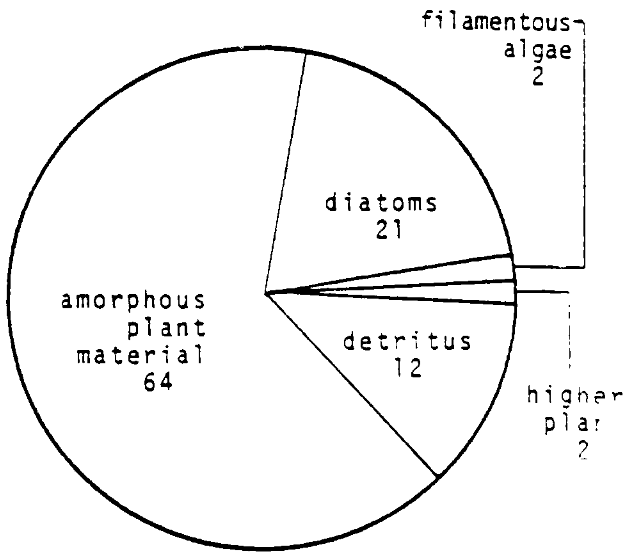


Figure F-15. Relative percent composition of major invertebrate community components by habitat types. Lockes Ranch Spring, June, 1980. N = total density of organisms used in calculation of percentages.

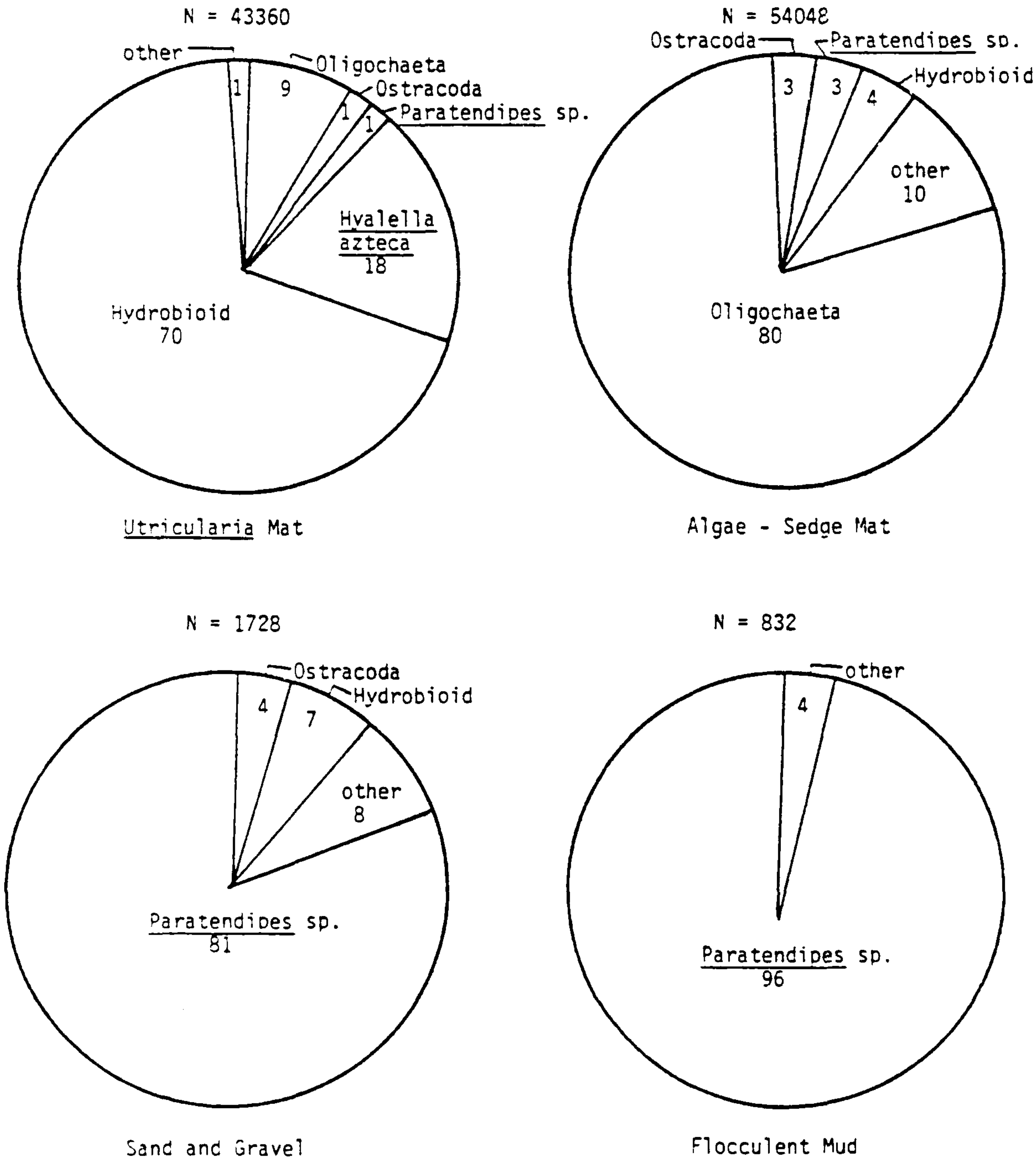


Figure F-16. Relative percent composition of major invertebrate community components by habitat types. Lockes Ranch Spring, July, 1980. N = total density of organisms used in calculation of percentages.

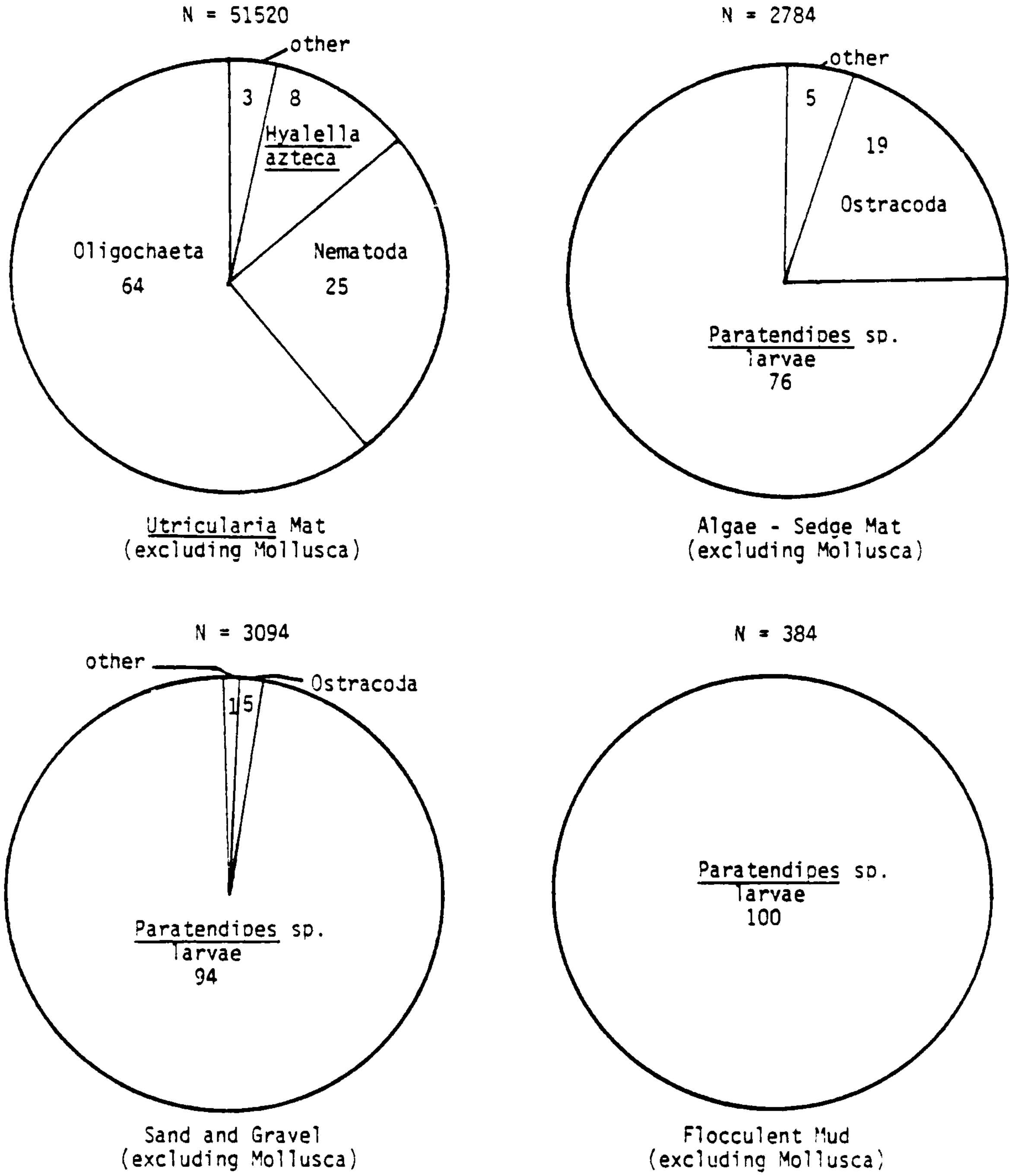


Figure F-17. Relative percent composition of major invertebrate community components by habitat types. Lockes Ranch Spring, August, 1980. N = total density of organisms used in calculation of percentages.

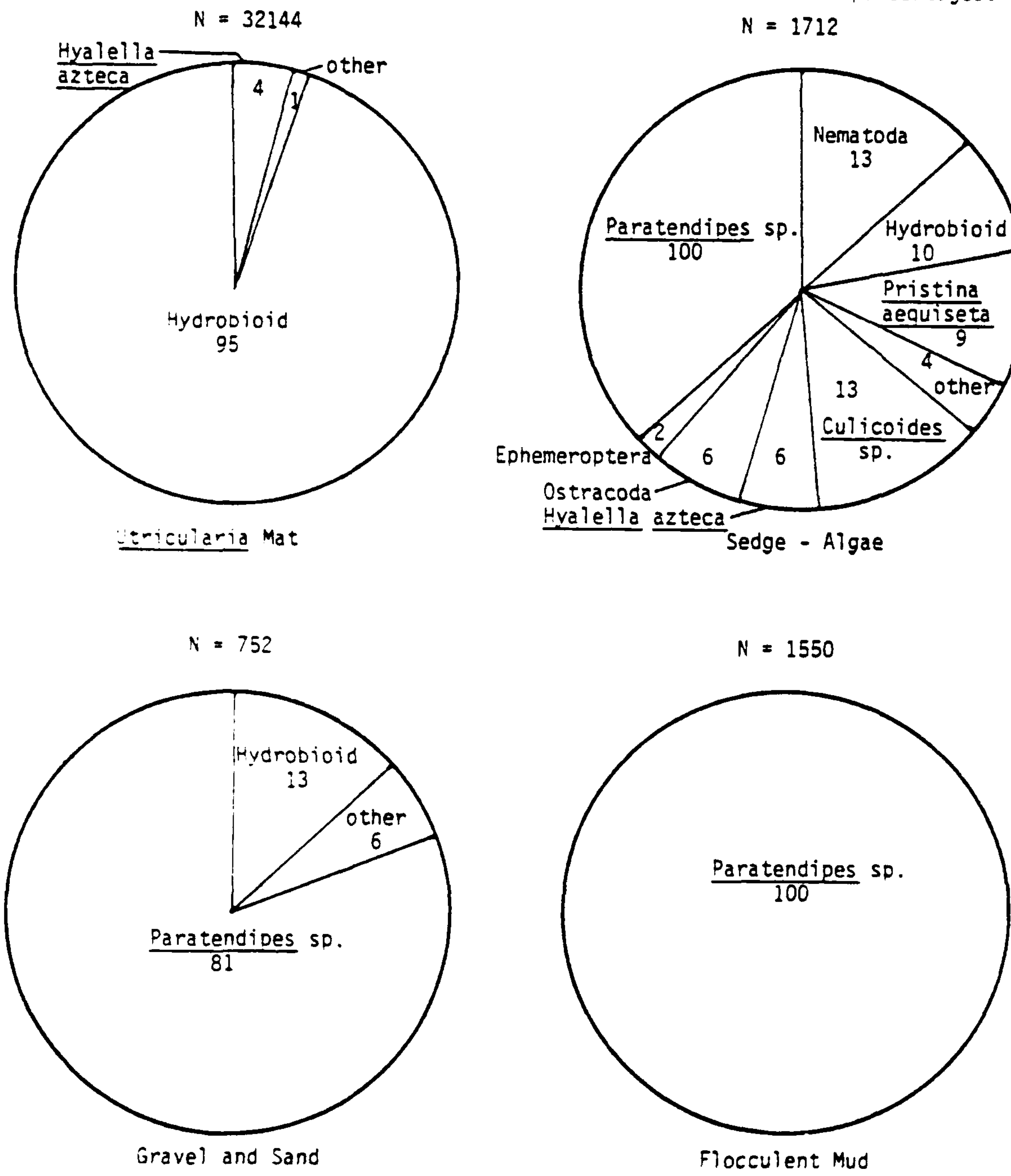


Figure F-18. Relative percent composition of major invertebrate community components by habitat types. Lockes Ranch Spring, September, 1980. N = total density of organisms used in calculation of percentages.

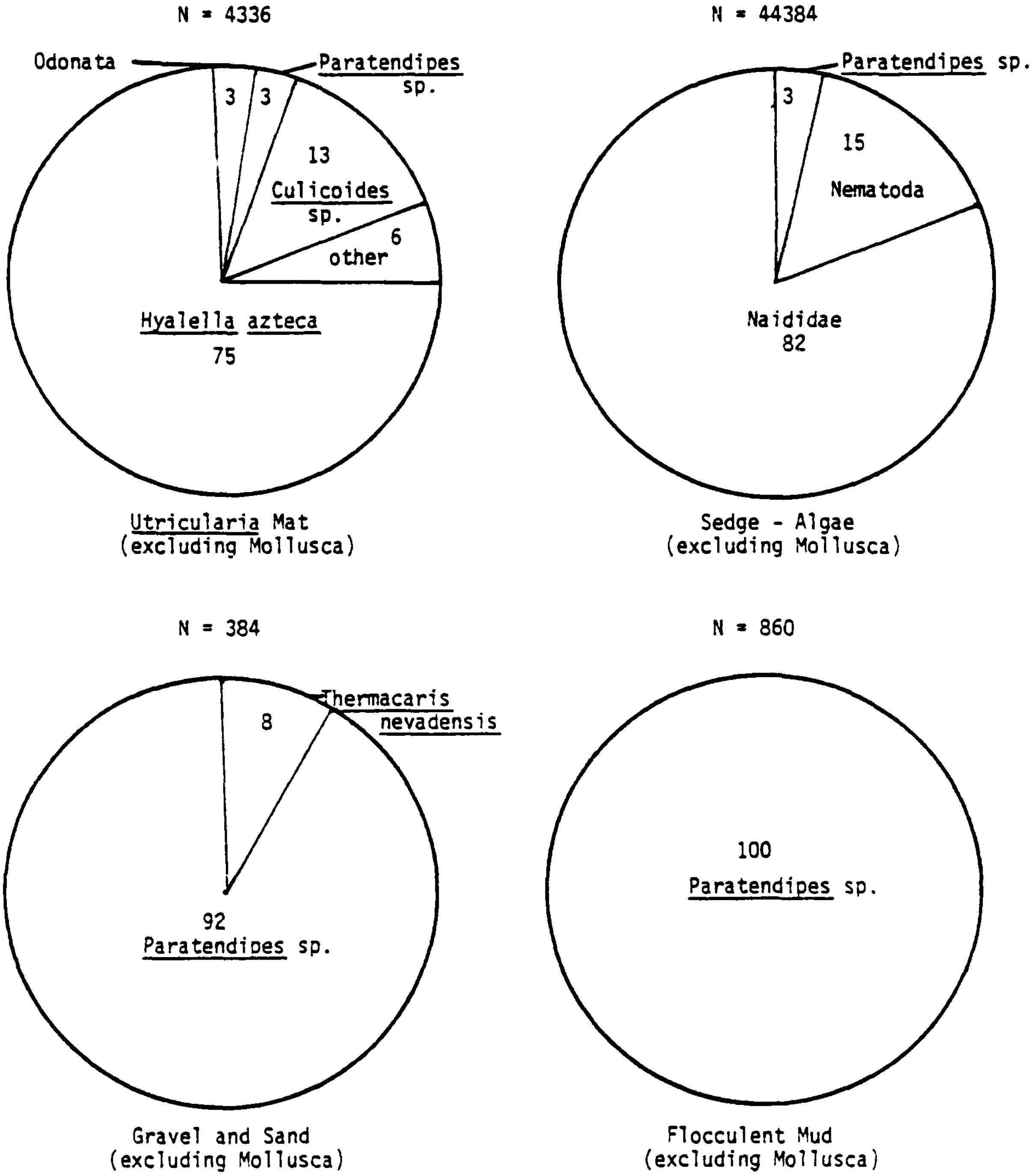


Figure F-19. Results of food habits for Crenichthys nevadae expressed as percentage volume of the total diet. Big Spring at Lockes Ranch, Nevada, June, 1980. N = 10.

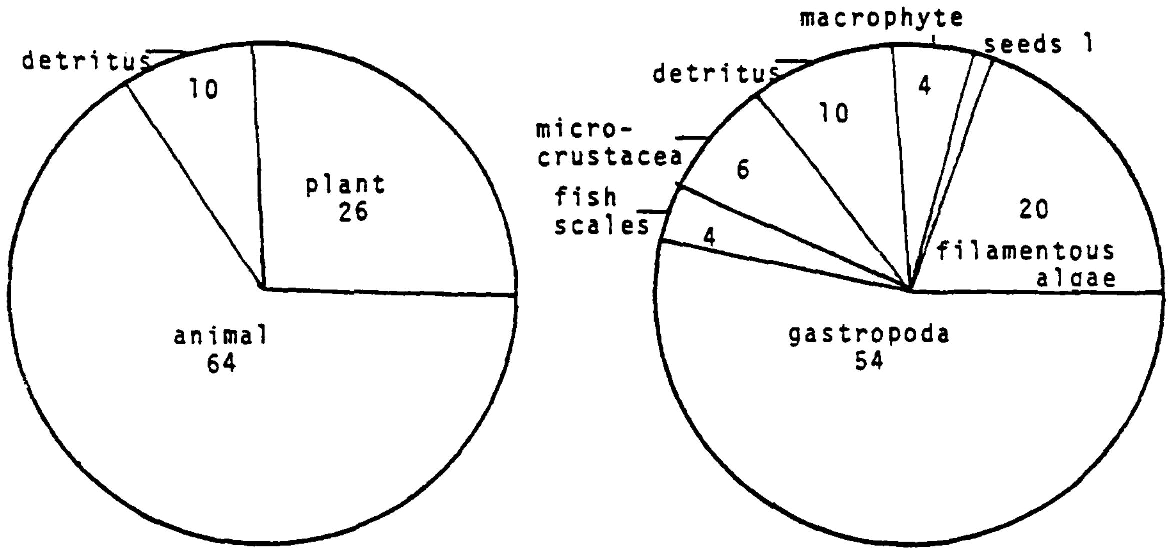


Figure F-20. Results of food habits for Crenichthys nevadae expressed as percentage volume of the total diet. Big Spring at Lockes Ranch, Nevada, July, 1980. N = 10.

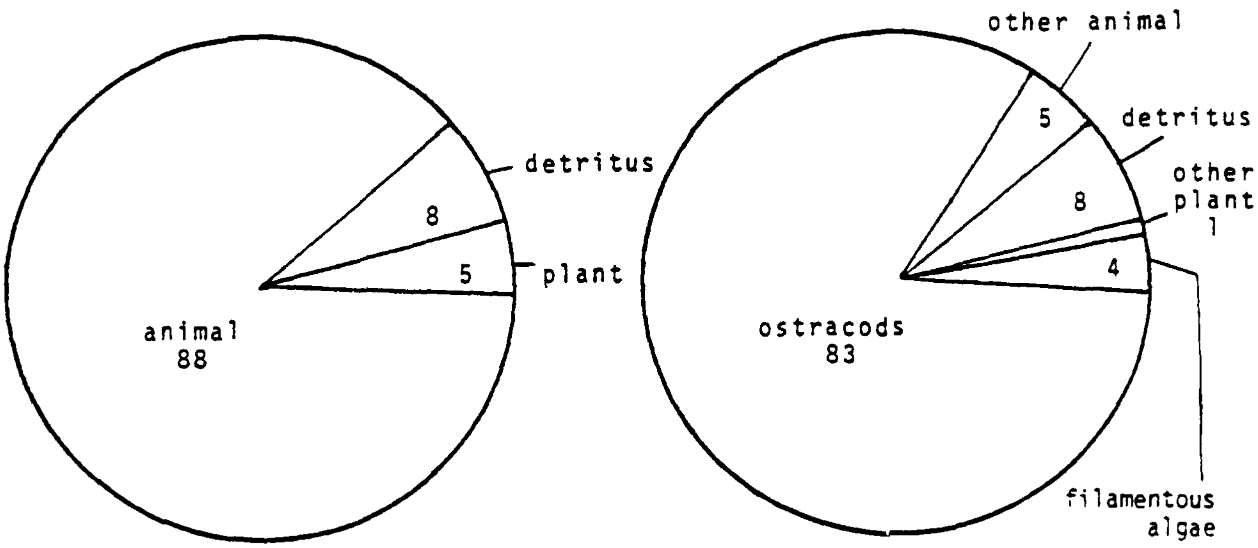


Figure F-21. Results of food habits for <u>Crenichthys</u> <u>nevadae</u> expressed as percentage volume of the total diet. Big Spring at Lockes Ranch, Nevada, August, 1980. N = 10.

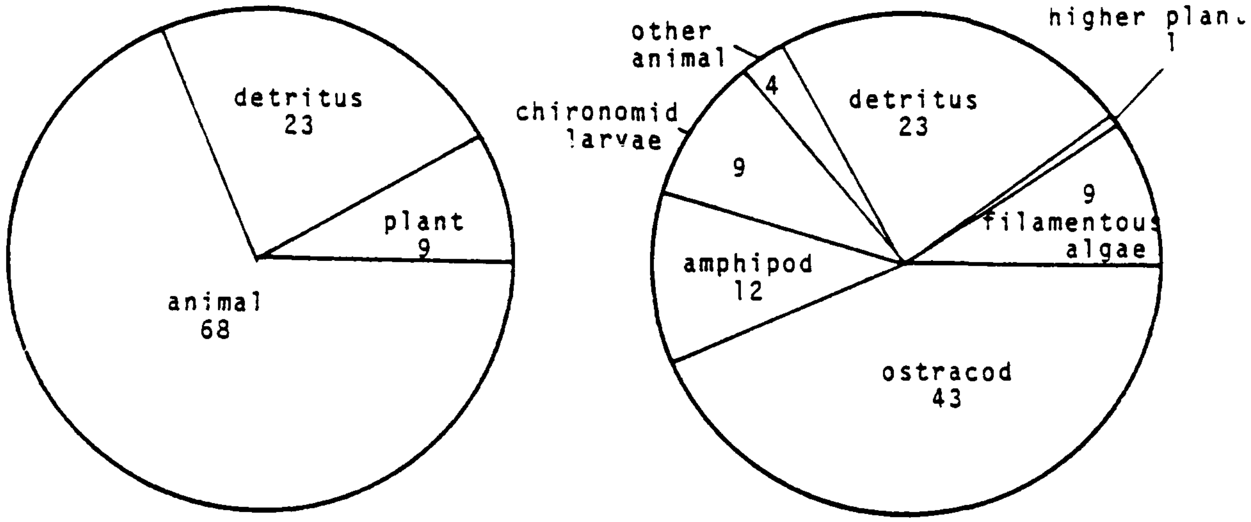


Figure F-22. Results of food habits for <u>Crenichthys</u> <u>nevadae</u> expressed as percentage volume of the total diet. Big Spring at Lockes Ranch, Nevada, September, 1980. N = 10.

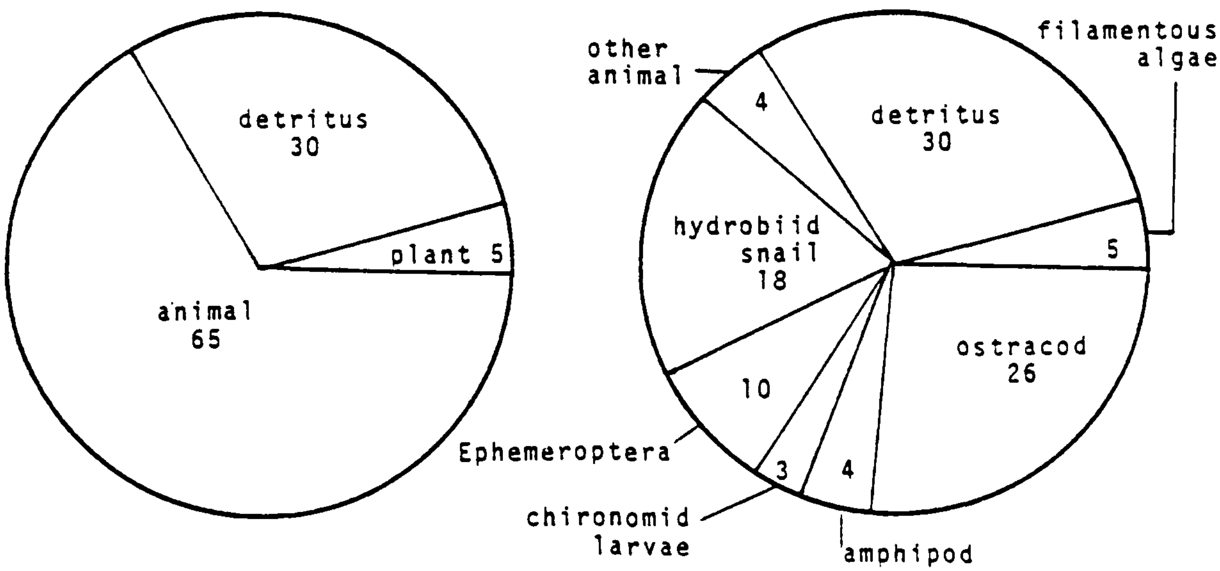


Figure F-23. Relative percent composition of major invertebrate community components by habitat types. Shoshone North Pond, June, 1980. N = total density of organisms used in calculation of percentages.

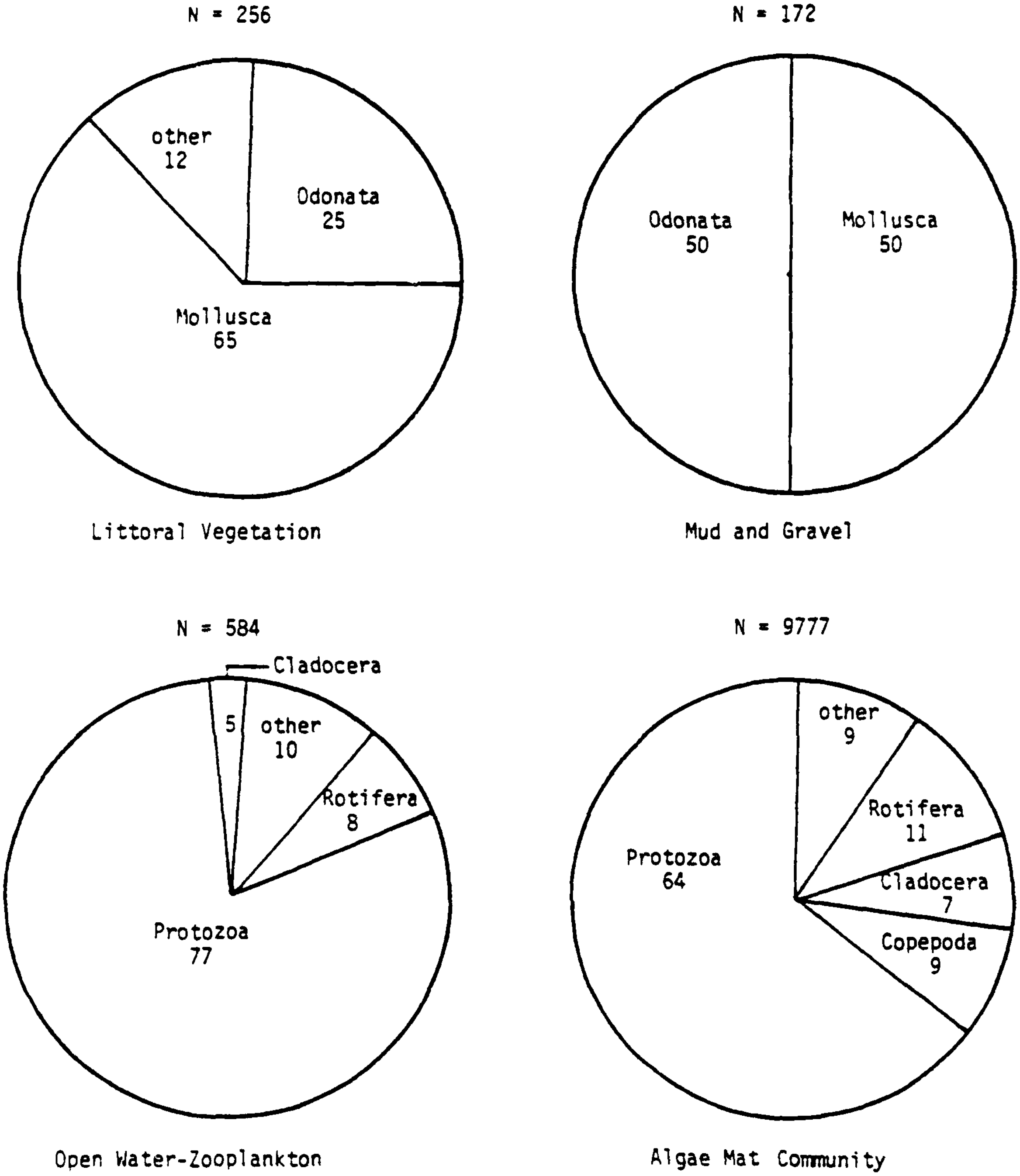


Figure F-24. Relative percent composition of major invertebrate community components by habitat types. Shoshone North Pond, July, 1980. N = total density of organisms used in calculations of percentages.

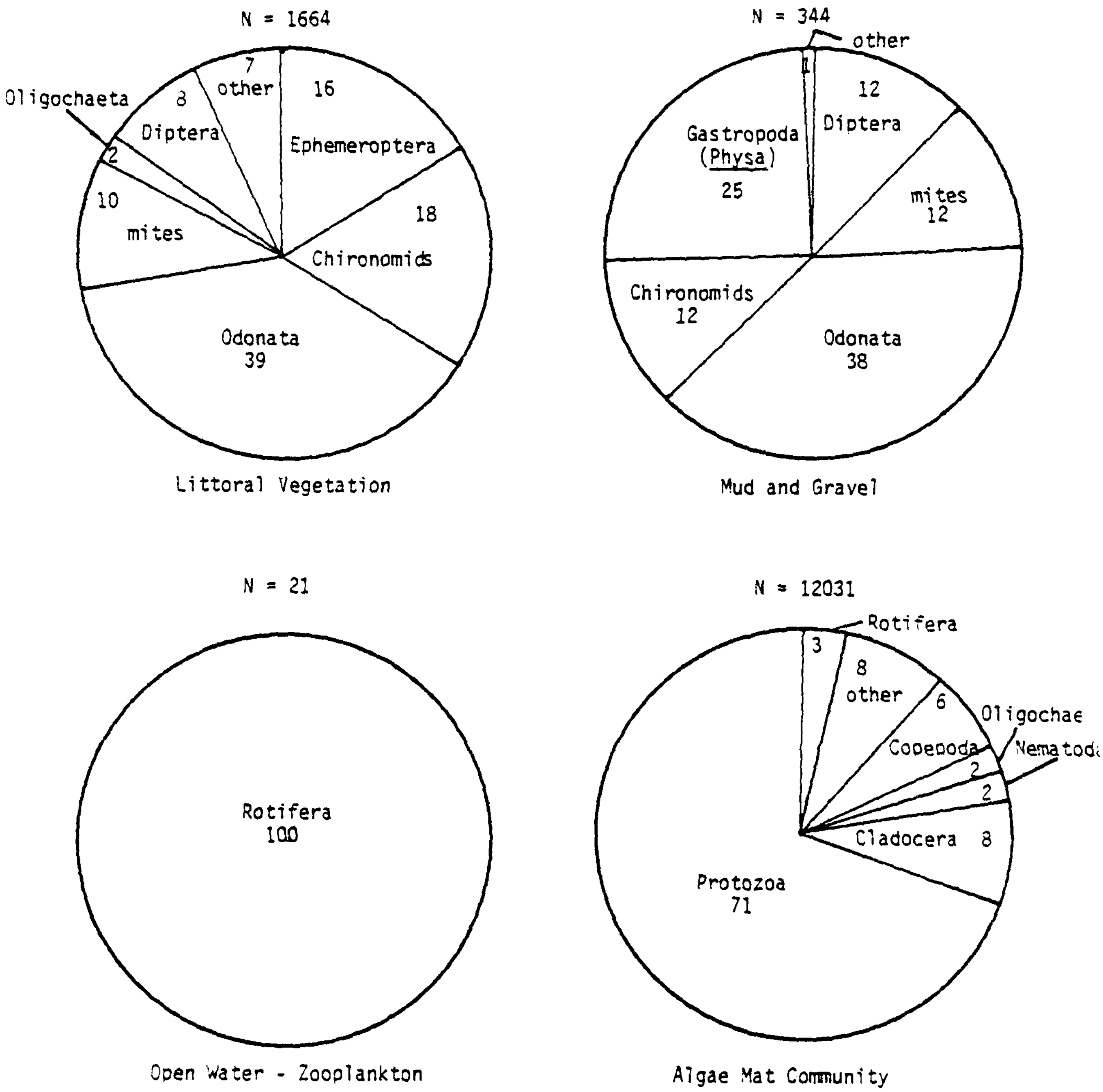
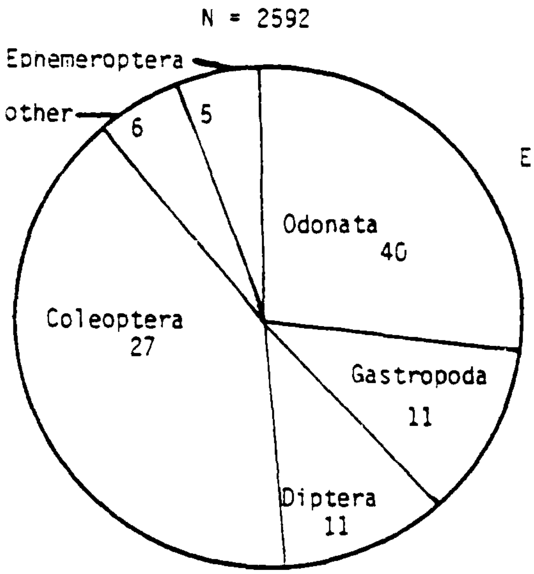
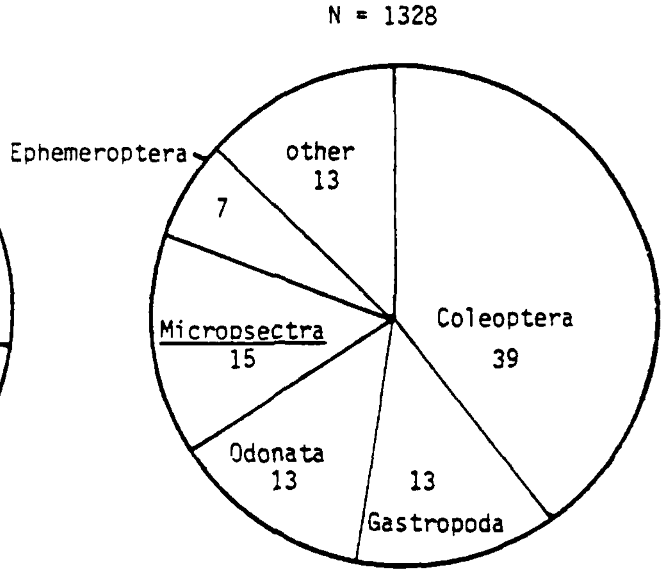


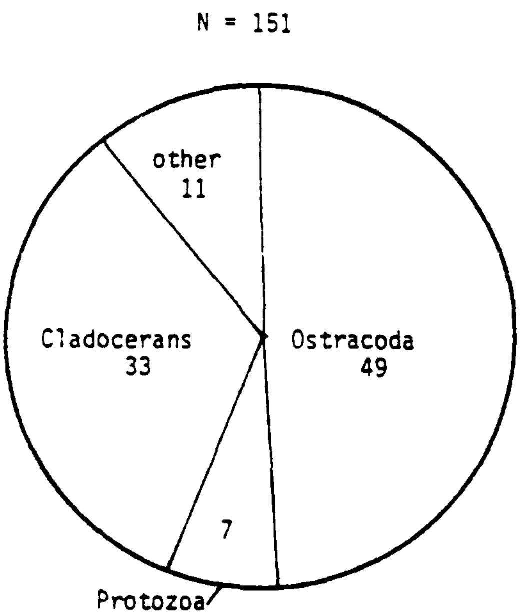
Figure F-25. Relative percent composition of major invertebrate community components by habitat types. Shoshone North Pond, August, 1980. N = total density of organisms used in calculation of percentages.



Deep Littoral Vegetation



Shallow Littoral Vegetation



Open Water (Drift)

Figure F-26. Relative percent composition of major invertebrate community components by habitat types. Shoshone North Pond, September, 1980. N = total density of organisms used in calculation of percentages.

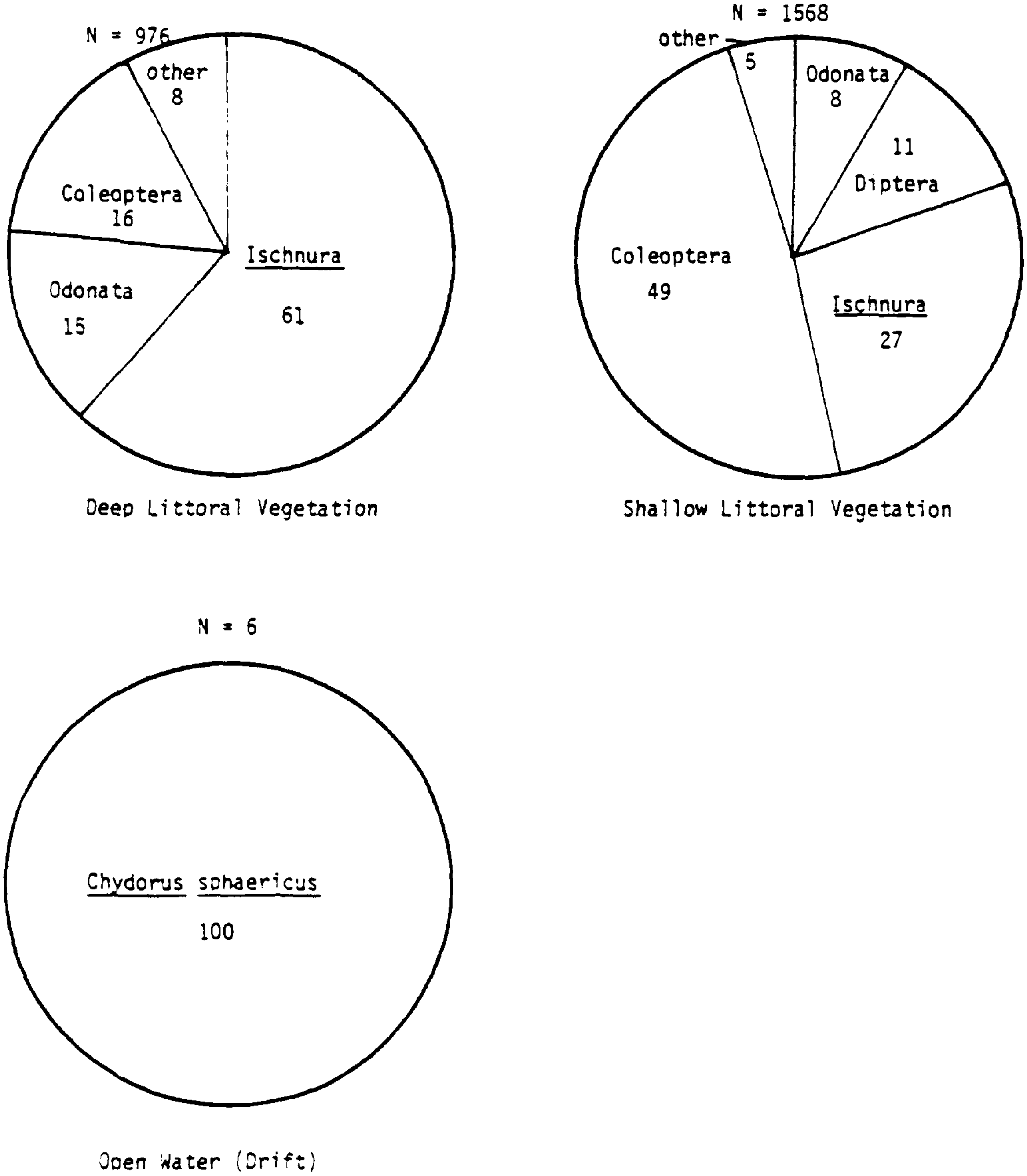


Figure F-27. Results of food habits for *Empetrichthys latos latos* expressed as percentage volume of the total diet. Manse spring, Pahrump Valley, Nevada, 1961-1963. N = 120.

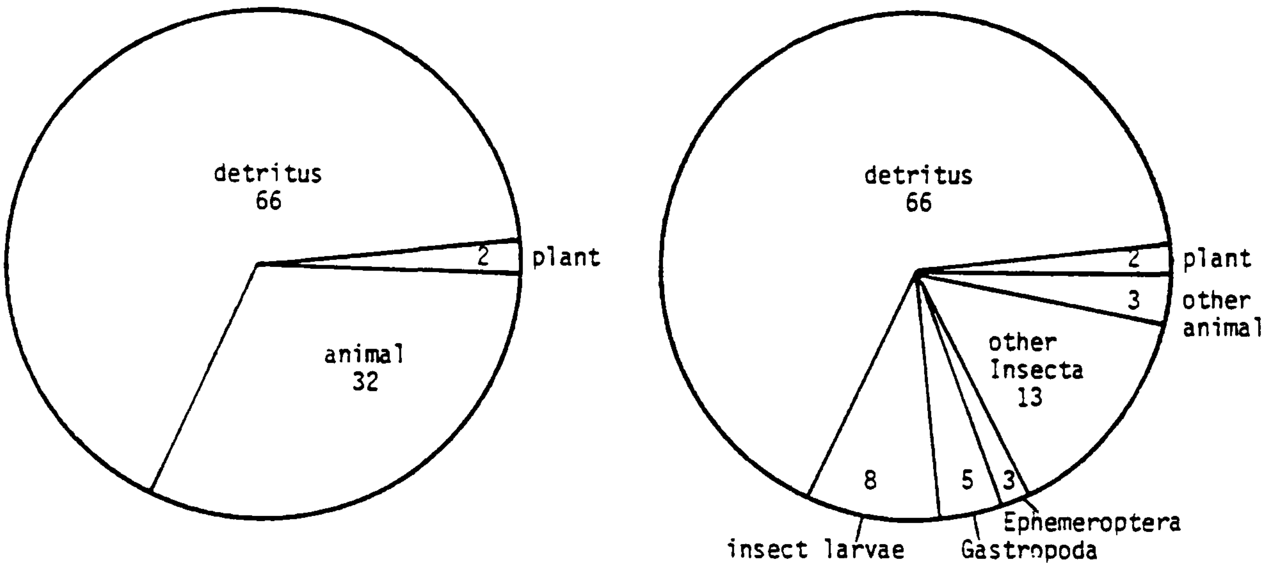


Figure F-28. Relative percent composition of major invertebrate community components by habitat types. Outflow of Ash Spring, June, 1980. N = total density of organisms used in calculation of percentages.

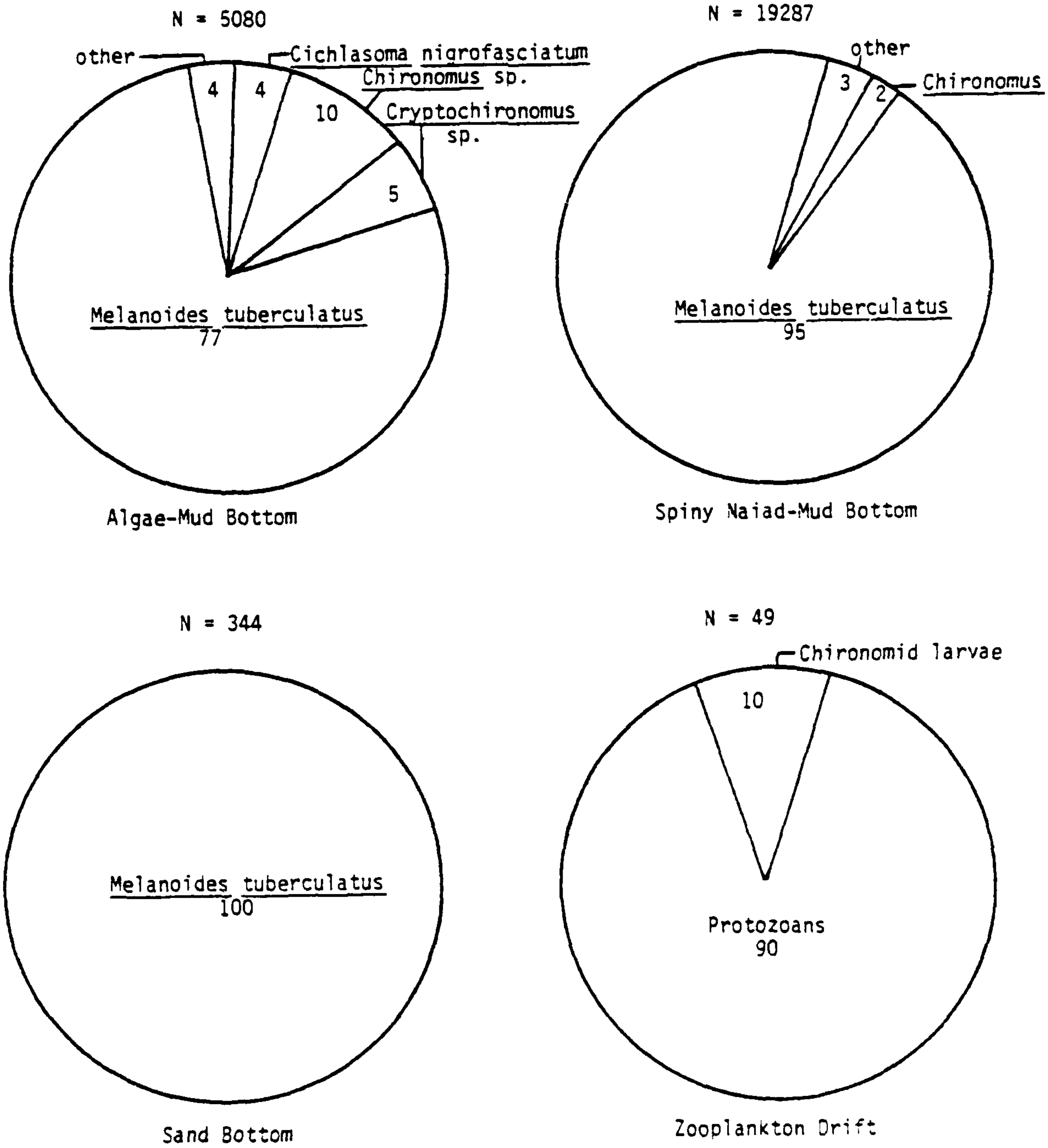


Figure F-29 . Relative percent composition of major invertebrate community components by habitat types. Outflow of Ash Spring, July, 1980. N = total density of organisms used in calculation of percentages.

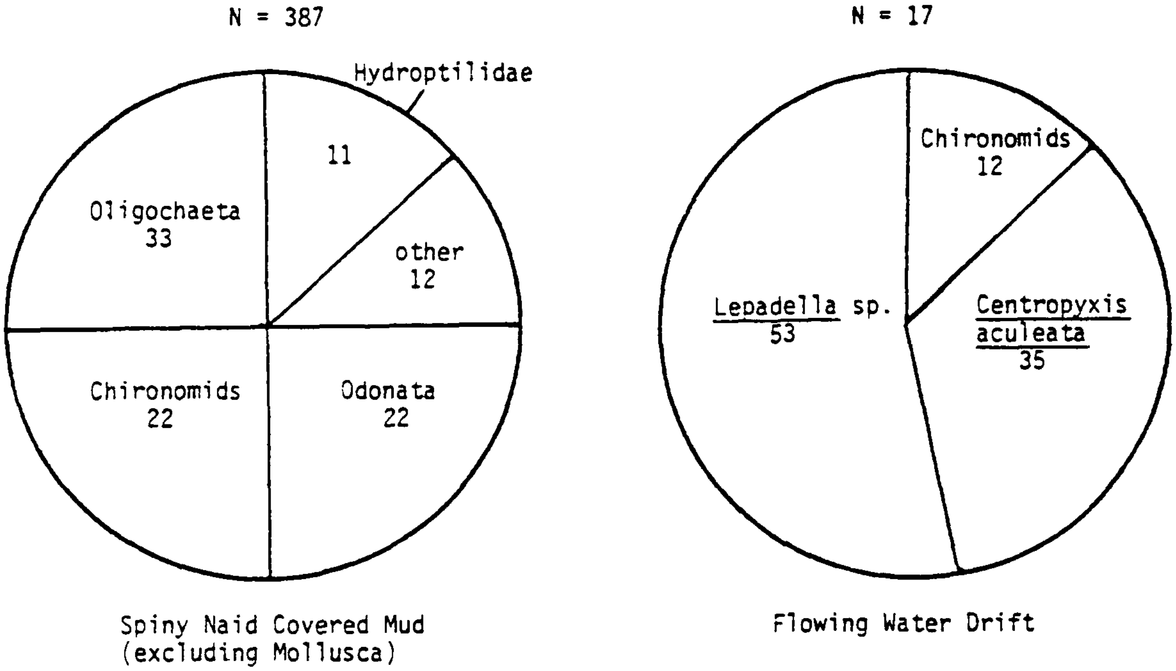


Figure F-30. Relative percent composition of major invertebrate community components by habitat types. Outflow of Asn Spring, August, 1980. N = total density of organisms used in calculation of percentages.

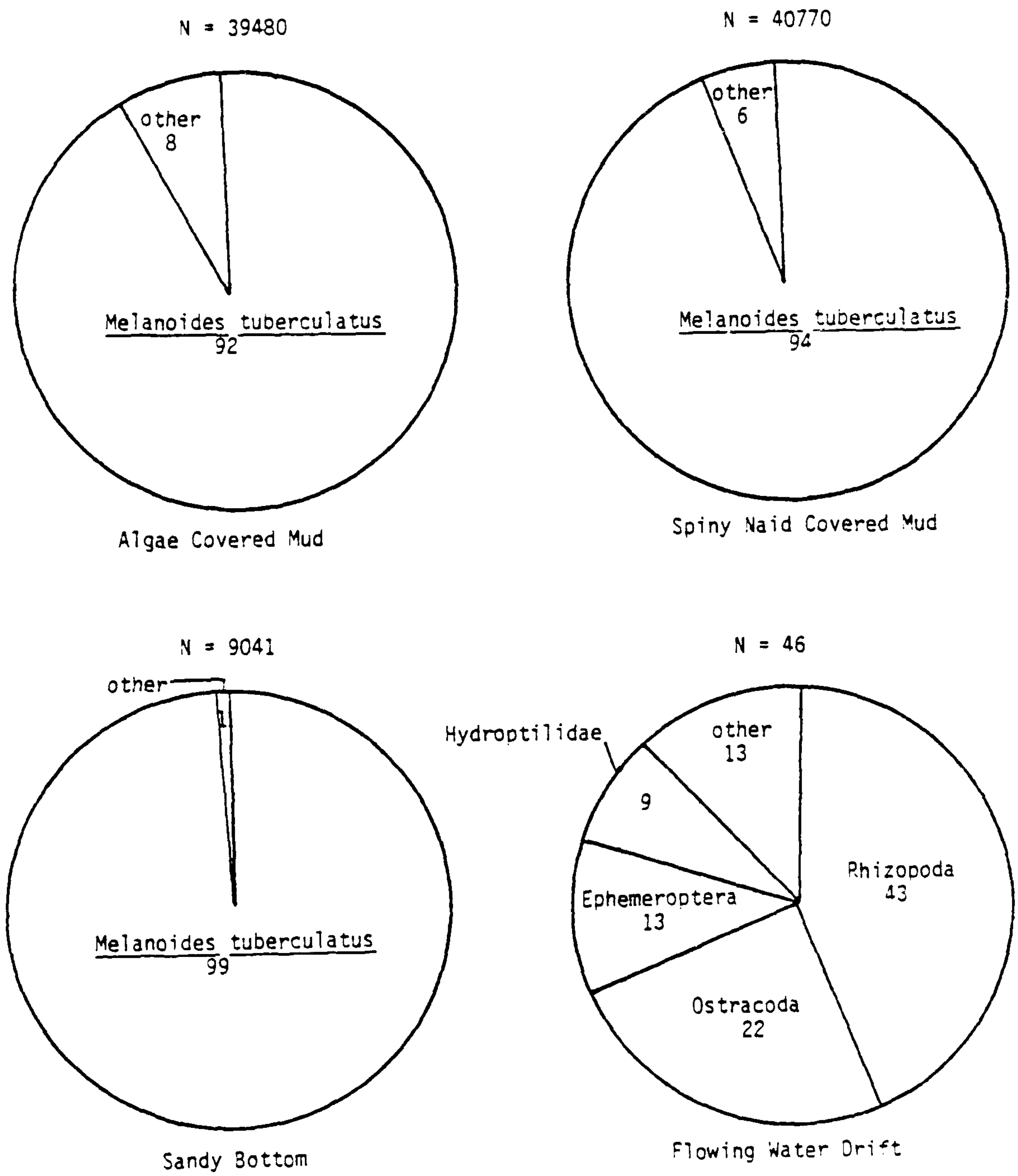


Figure F-31. Relative percent composition of major invertebrate community components by habitat types. Ash Spring, September, 1980. N = total density of organisms used in calculation of percentages.

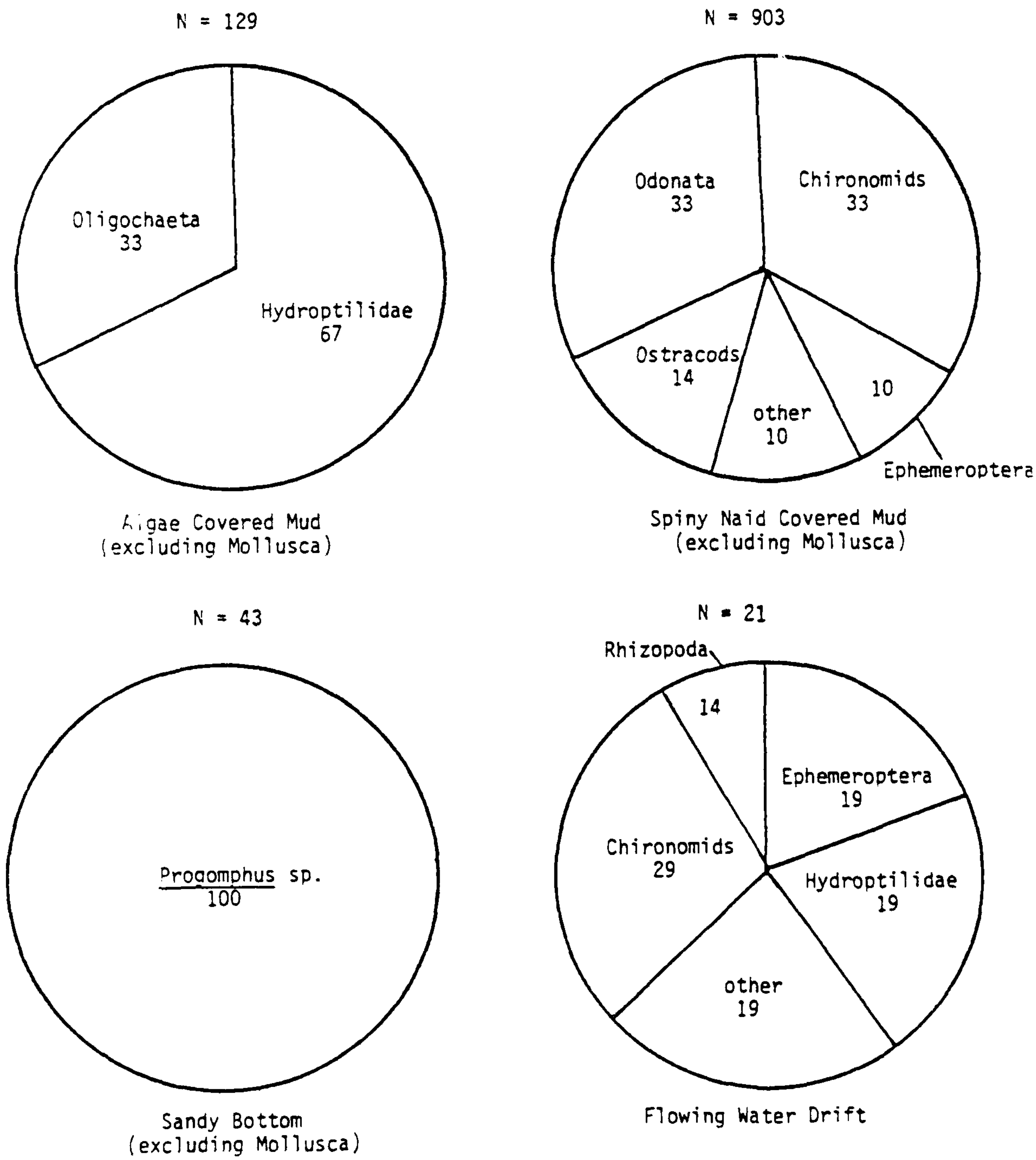


Figure F-32. Results of food habits for Rhinichthys osculus expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, June, 1980. N = 10.

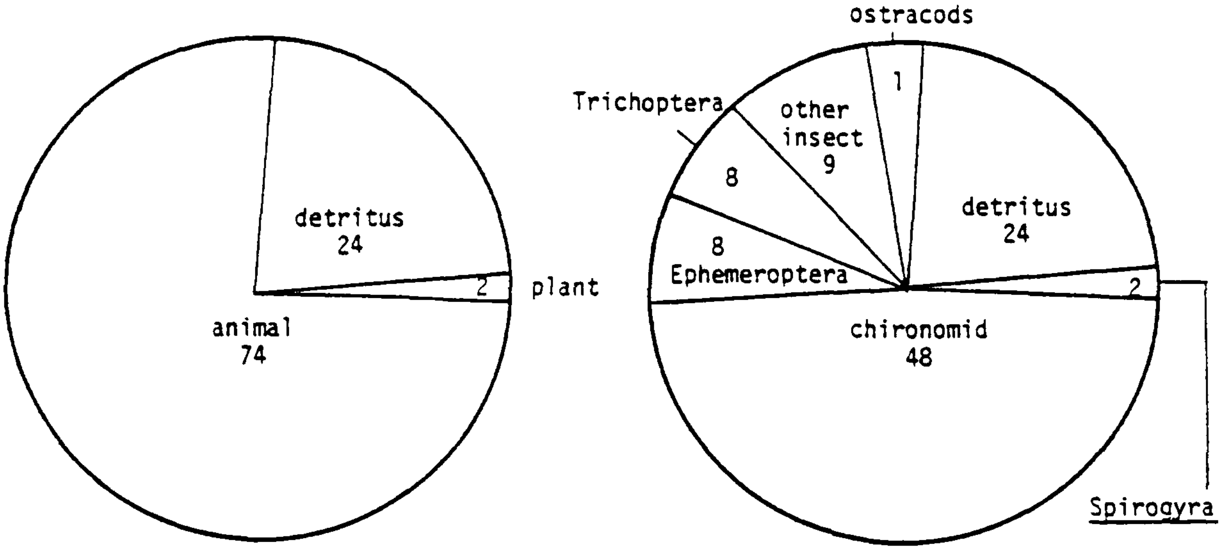


Figure F-33. Results of food habits for Rhinichthys osculus expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, July, 1980. N = 10.

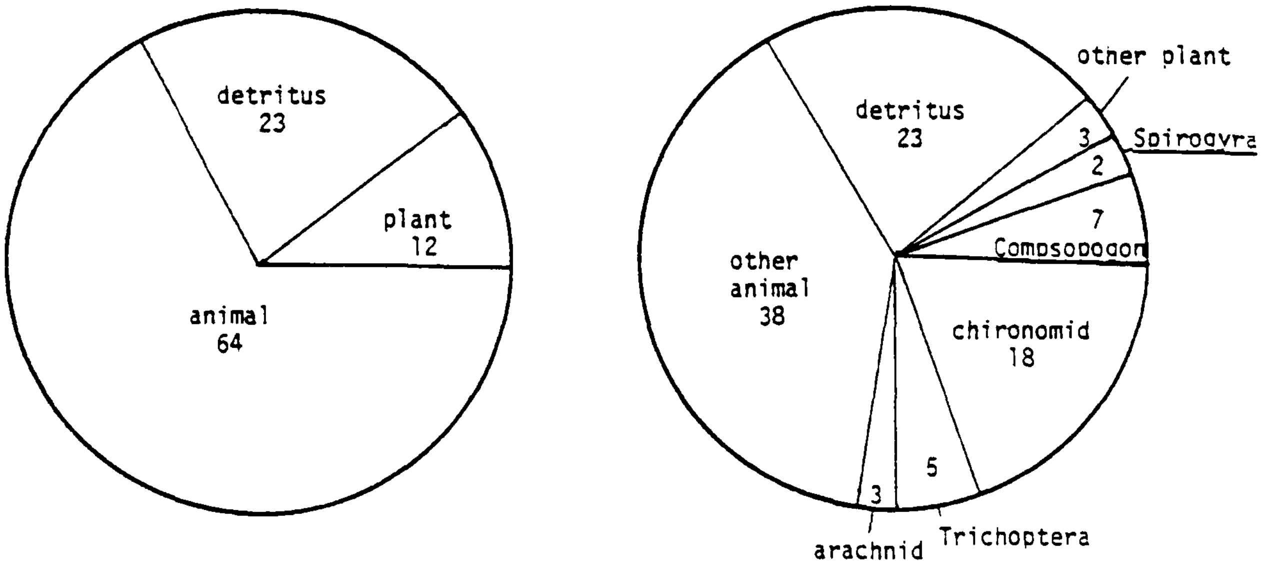


Figure F-34. Results of food habits for *Rhinichthys osculus* expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, August, 1980. N = 10.

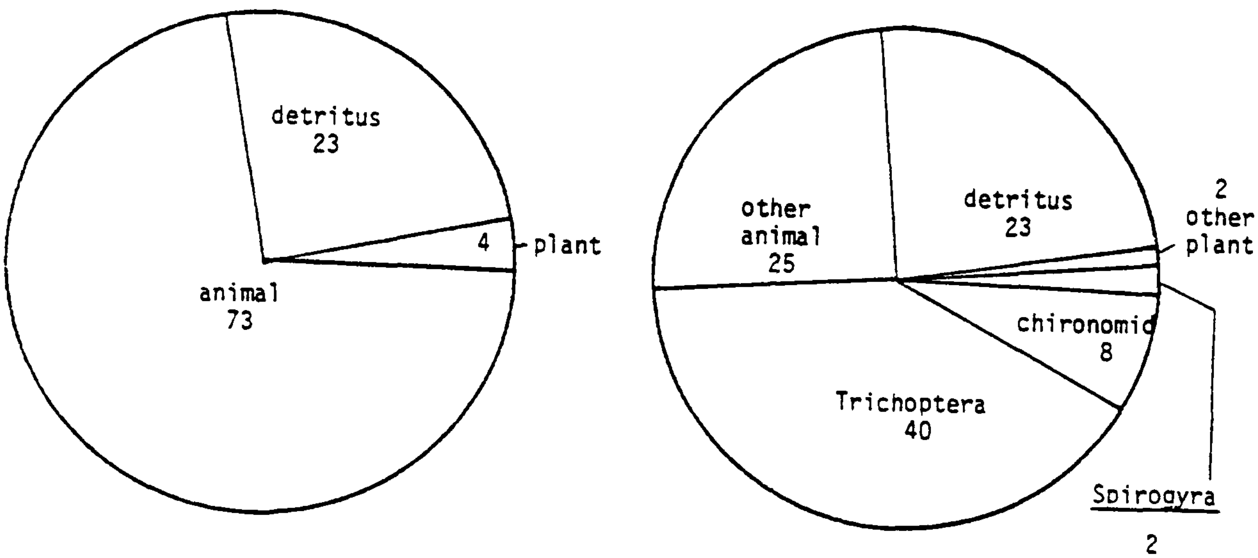


Figure F-35. Results of food habits for *Gambusia affinis* expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, September, 1980. N = 11.

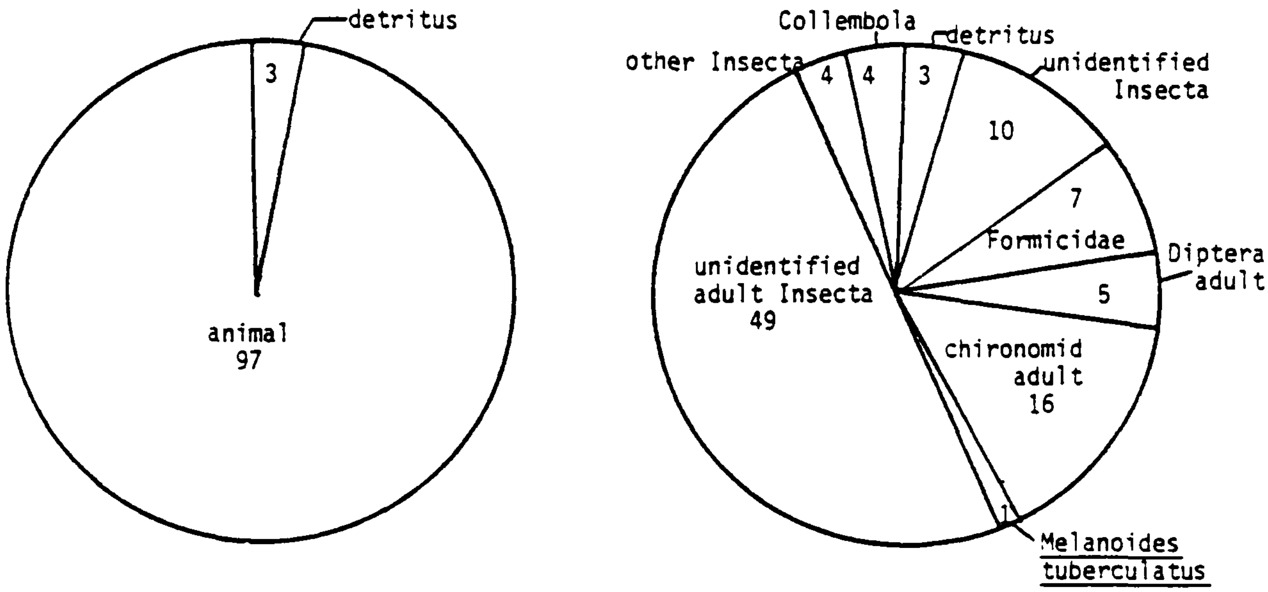


Figure F-36. Results of food habits for *Poecilia mexicana* expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, August, 1980. N = 10.

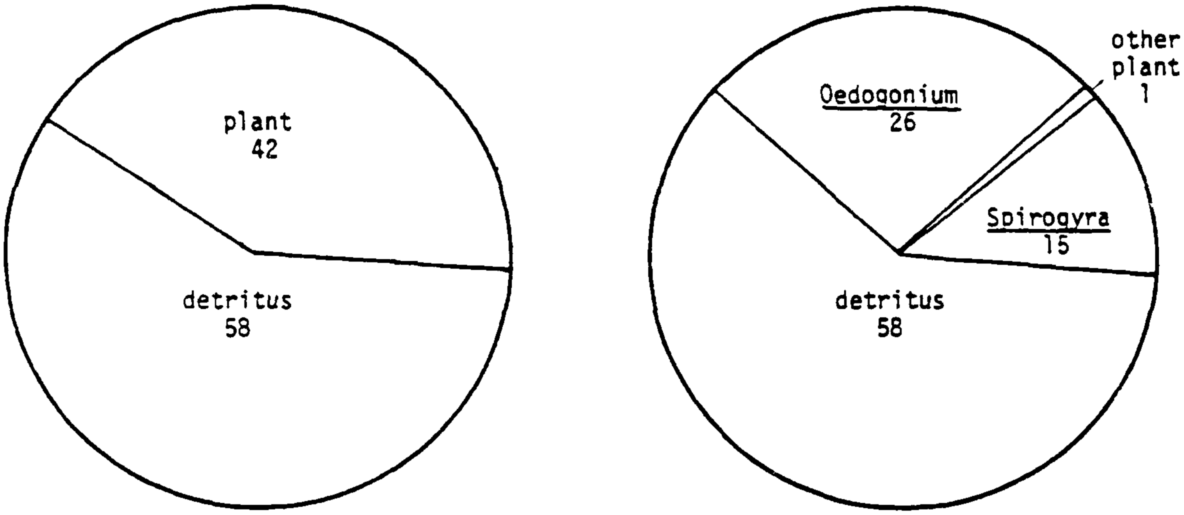


Figure F-37. Results of food habits for *Poecilia mexicana* expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, September, 1980. N = 10.

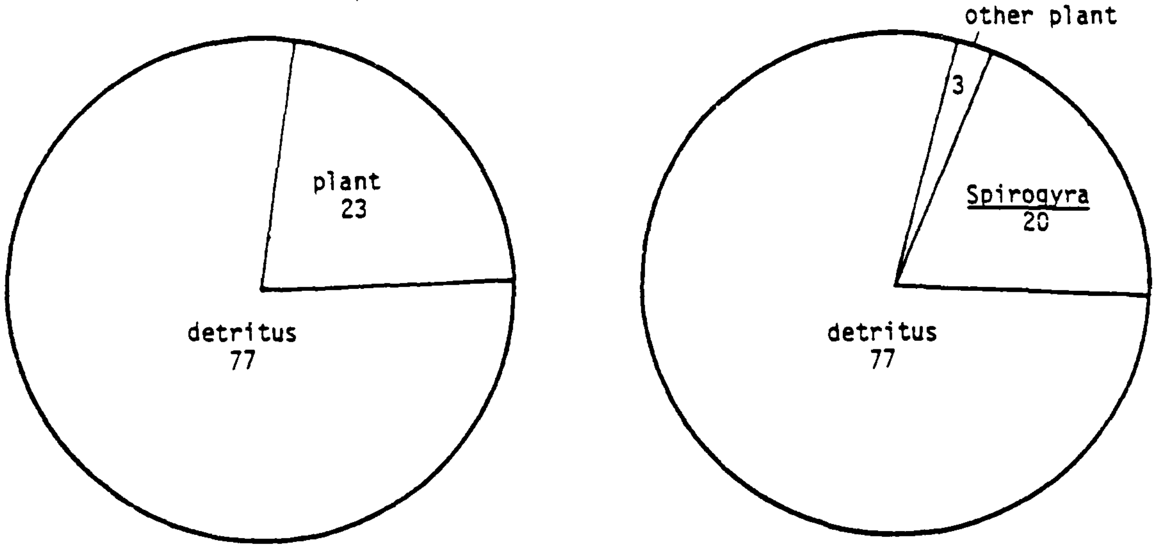


Figure F-38. Results of food habits for Poecilia mexicana expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, June, 1980. N = 10.

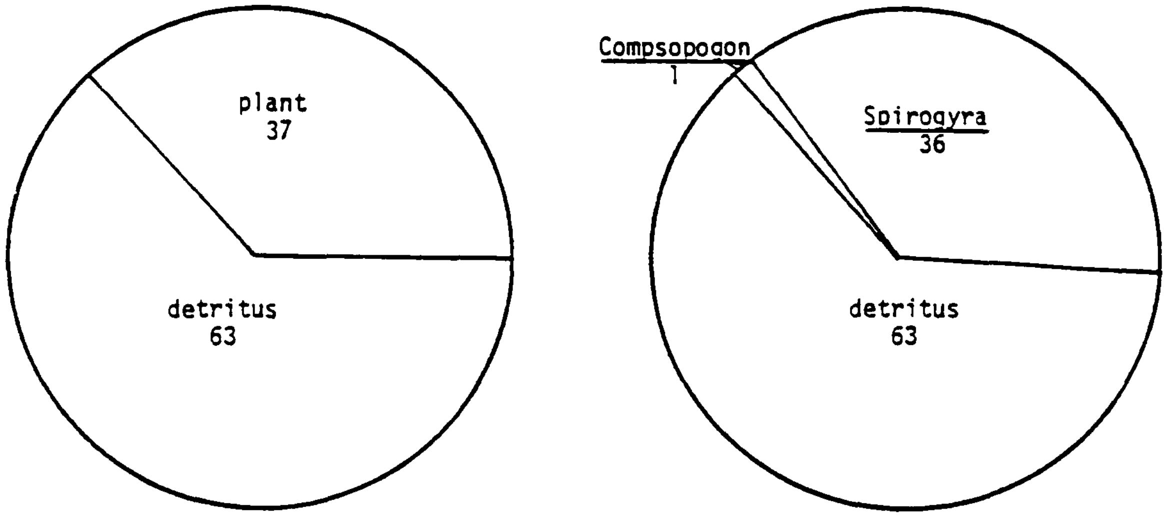


Figure F-39. Results of food habits for Poecilia mexicana expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, July, 1980. N = 10.

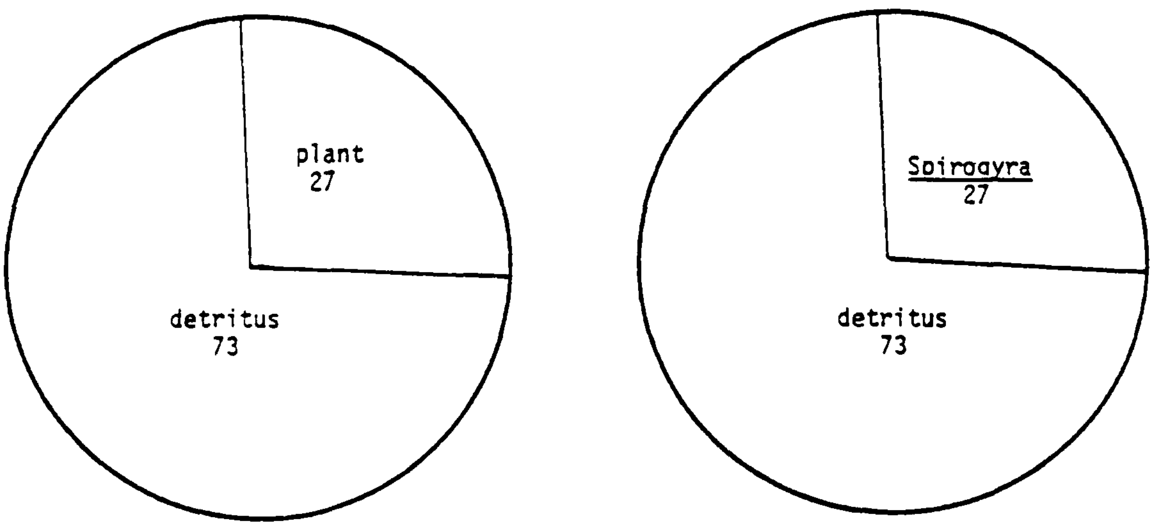


Figure F-40. Results of food habits for Cichlasoma nigrofasciatum expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, June, 1980. N = 10.

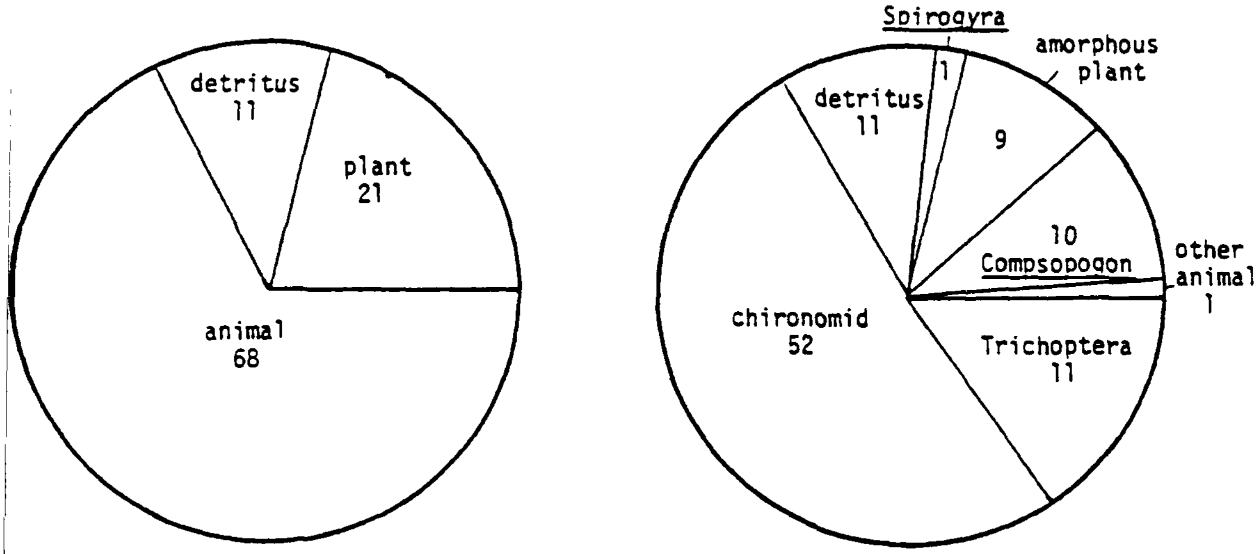


Figure F-41. Results of food habits for Cichlasoma nigrofasciatum expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, July, 1980. N = 10.

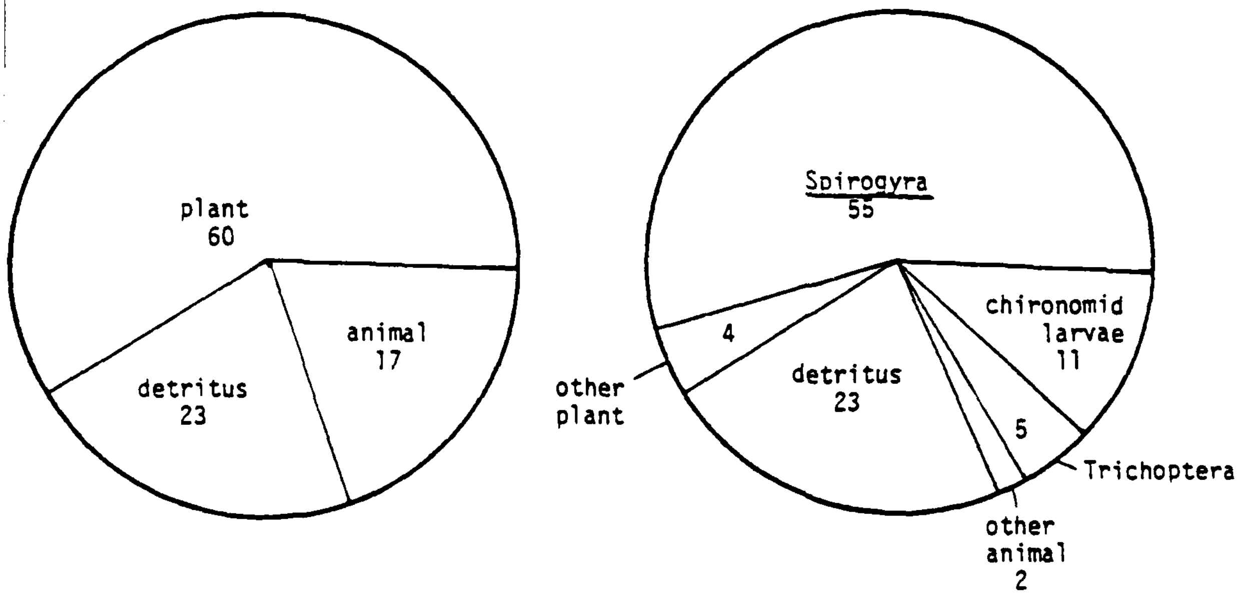
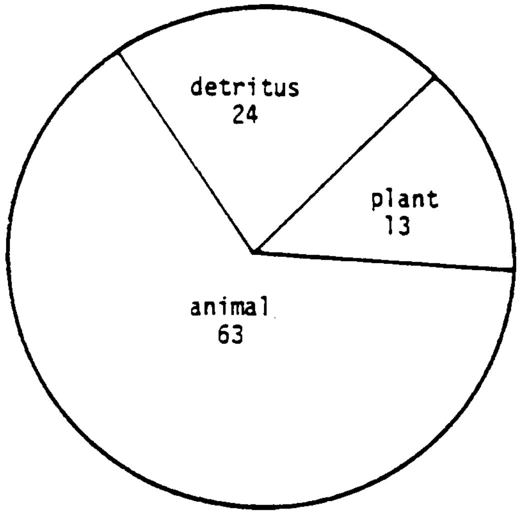


Figure F-42. Results of food habits for Cichlasoma nigrofasciatum expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, August, 1980. N = 10.



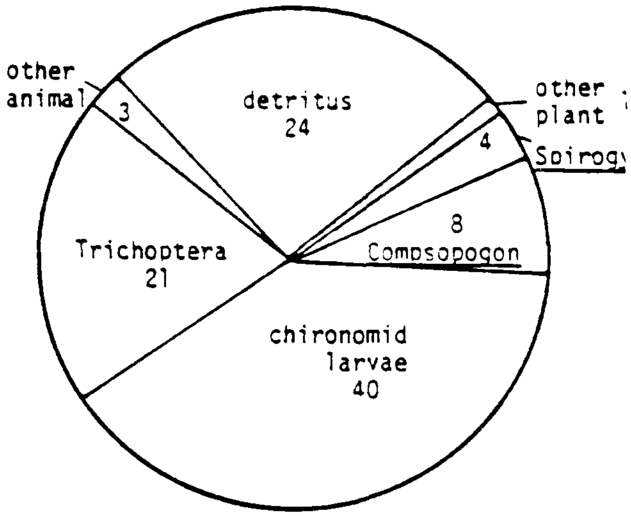
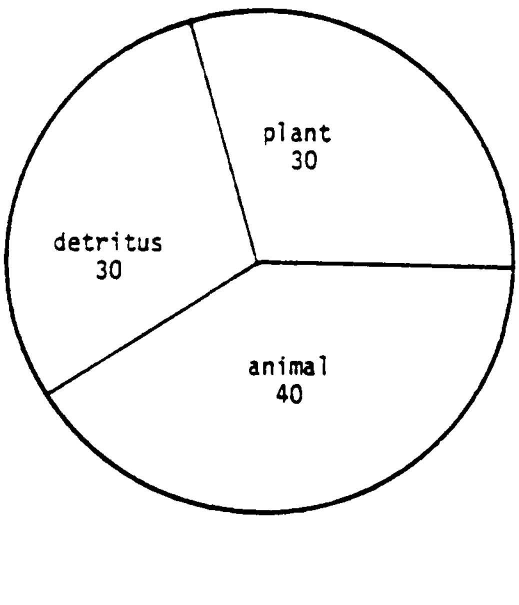
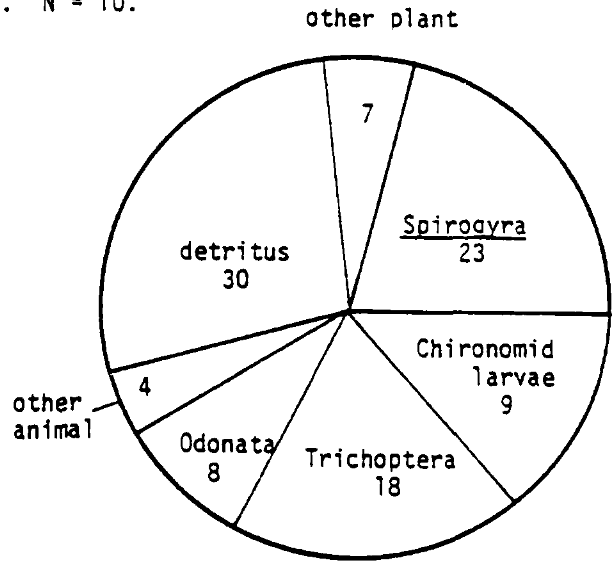


Figure F-43. Results of food habits for Cichlasoma nigrofasciatum expressed as percentage volume of the total diet. Outflow of Ash Spring, Nevada, September, 1980. N = 10.





APPENDIX B-2

INTENSIVE AQUATIC BIOLOGICAL STUDIES IN UTAH, 1980

Final Summary Report

AQUATIC BIOLOGICAL STUDY OF A SPRING COMPLEX IN SNAKE VALLEY, UTAH

Submitted to

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804 Anacapa Street
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Prepared by

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and
Paul B. Holden

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November 1980

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ABSTRACT

An aquatic resource survey was conducted on the Leland Harris Springs complex in western Utah during June, July, August, and September 1980. Parameters examined included water quality and populations of benthic invertebrates, plankton, and fish. Primary emphasis was on distribution and abundance of fish populations. Least chub and Utah chub were the only fish present and were abundant and widely distributed throughout the spring complex. Microdistribution of fish was influenced by physical conditions in the marsh areas such as low nighttime O_2 concentrations and high daytime temperatures which resulted in fish concentrating in the springheads which exhibited more stable physical conditions. Least chub were found to be diurnal with maximum activity occurring during the day.

Two year classes of least chub were present during the sample periods. Utah chub populations contained a distinct young-of-the-year and juvenile age class and an uncertain number of older age classes.

Stomach analyses of small chubs (<50 mm) and least chubs indicated that they consumed the same food items. Seasonal changes in the dietary habits of both fish was evidenced by a change from zooplankton to algae and detritus as the primary food between July and August.

INTRODUCTION

The MX missile system has been proposed by the U.S. Air Force for deployment in the desert area of western Utah and central Nevada. HDR Sciences has been contracted by the Air Force to assess the potential environmental impacts of the proposed MX project. The study reported on herein is a portion of those impact studies and was conducted for HDR Sciences under Contract HDR/RPA-11.

This study involved an analysis of the aquatic ecosystem in a spring in Snake Valley, located in west-central Utah.

The Leland Harris Springs complex was chosen as the site for the inventory because it contained the largest remaining population of least chubs (*Iotichthys phlegethontis* Cope) of any known site. This spring area has persisted in a relatively unmodified state in the midst of agricultural development activities which have altered many of the other springs of the Snake Valley.

The Leland Harris complex is a group of springs and associated marsh area located south of Partoun in Snake Valley, part of the Bonneville and Great basins (Figure 1). The Great Basin is typified by parallel north-south mountain ranges separated by broad desert basins (Christiansen 1951). The Snake Valley is one of these basins which remained after the desiccation of Pleistocene Lake Bonneville. Several fish maintained a relict existence in the Bonneville Basin after the disappearance of Lake Bonneville, including *Rhynichthys osculus relicus* Hubbs, a Great Basin subspecies of dace, *Salmo clarki utah* Suckley, Utah cutthroat, and the least chub.

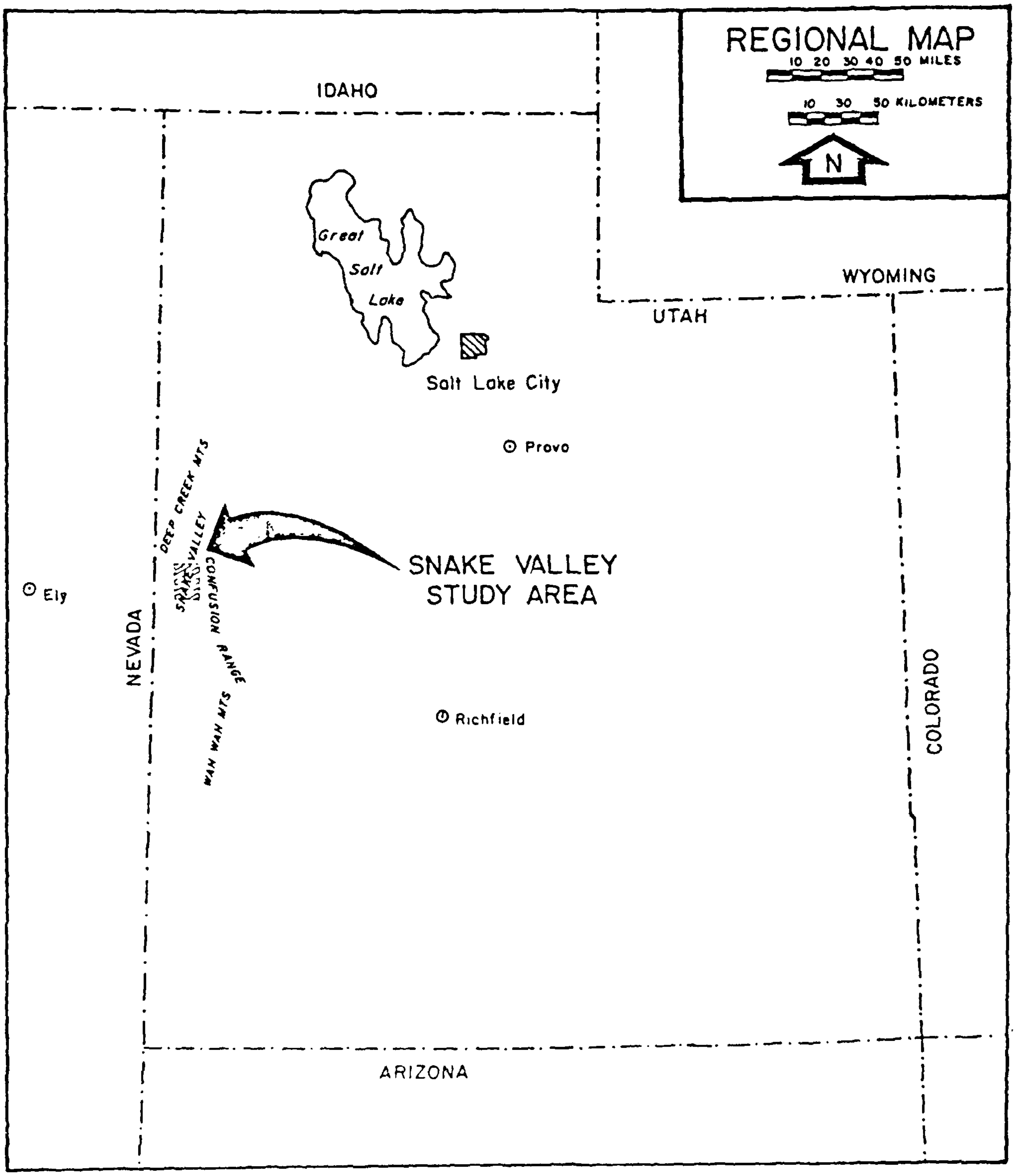

Figure 1. Map showing the location of the study area.

<u>Rhynichthys</u> <u>osculus</u> <u>relicus</u> is now extinct due primarily to deterioration of its aquatic habitat as a result of agricultural practices (Hubbs et al. 1974). The Utah cutthroat remains in the Deep Creek Mountains and the least chub is still found in Snake Valley, primarily in Leland Harris Springs complex.

The least chub has been classified as either rare or endangered by the American Fisheries Society, the Utah Division of Wildlife Resources, and the Bonneville Chapter of the American Fisheries Society (Holden et al. 1974). It was formerly common throughout the Great Basin drainage (Sigler and Miller 1963). Records of former distribution include Iron County, Utah, in 1936 (Hubbs and Miller 1948) and Big Cottonwood Creek near Salt Lake City in 1954 (Pendleton and Smart 1954). Present distribution of the least chub is limited to a few spring-marsh complexes in Snake Valley (Crawford 1979; Workman et al. 1979).

Primary objectives in this study, especially in reference to the least chub, were to determine the range and variability of aquatic biological resources within the area; document taxonomic diversity and identify those variables that form the most accurate predictors of the location of aquatic biologic resources within the area.

SITE DESCRIPTION

An overall map of the Leland Harris Springs complex locating the two main areas under study is presented in Figure 2. Study Area 1, a 100 m by 100 m square, was composed of several springs associated with open pond areas and a number of apparently isolated springs and ponds (Figure 2). Study Area 2, also 1 hectare in size, primarily comprised Spring 1, its channel, and the marsh below it (Figure 2). This second area was monitored because previous studies (Crawford 1979; Workman et al. 1979) had been conducted at this site. Also, it represented a different type of spring-marsh system, one in which the spring contributed more flow to the marsh than springs in Study Area 1. The marshes also contained an additional vegetation type, bullrushes, which were not found in Study Area 1. Other less intensively studied areas within the complex included Spring 10 and its associated marsh area located immediately east of Study Area 1 and Spring 2 in the southern end of the complex (Figure 2). Site descriptions of each pond and/or spring on which data were collected are included in Table 1. Locations of the individual springs and ponds within Study Area 1 are presented in Figure 3. Aerial photos on which Figure 2 was based are presented in Appendix 1.

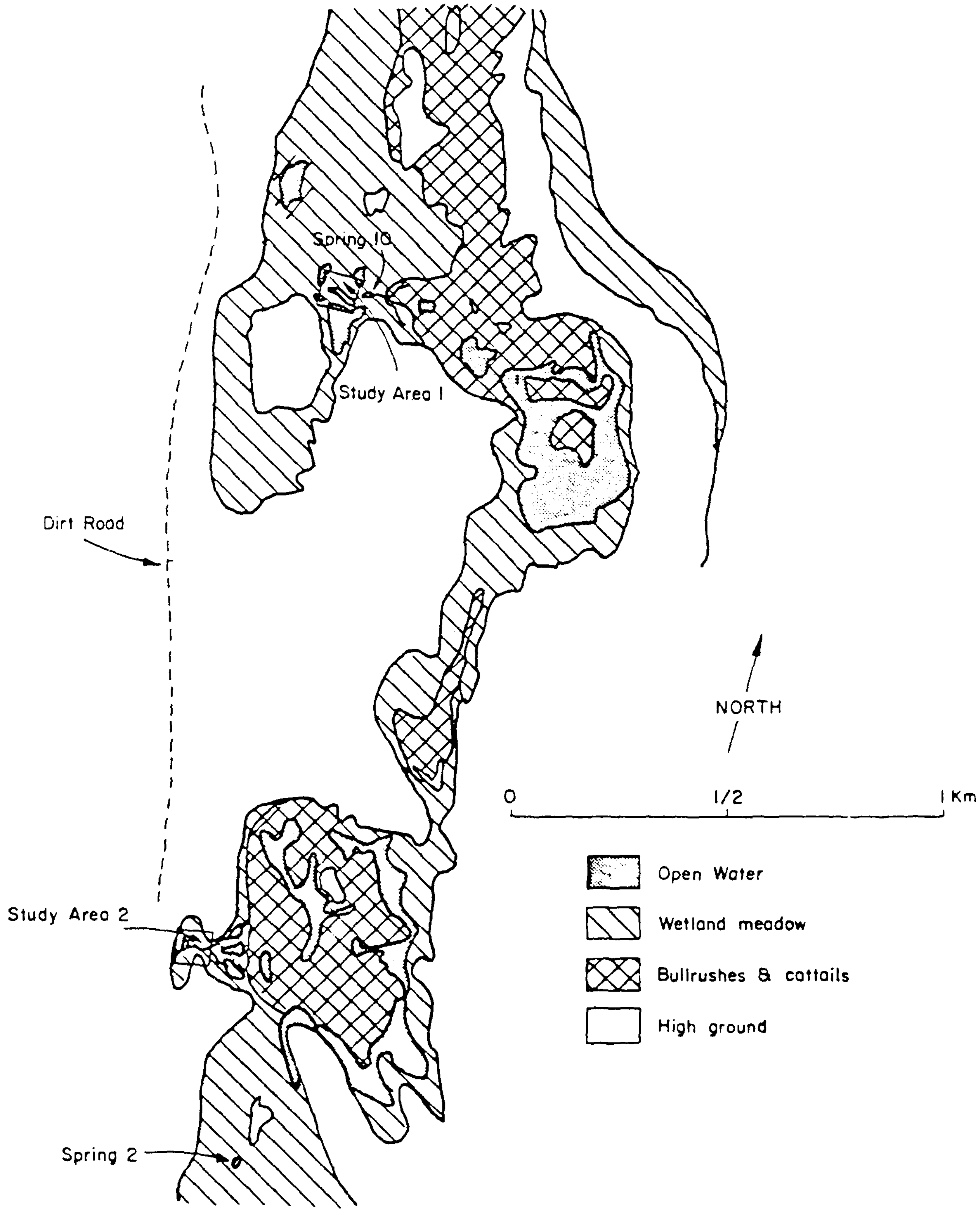

Figure 2. Map of Leland Harris Springs Complex denoting location of study areas.[1]

[1]Based on aerial photos - June 1980.

Table 1. Site descriptions, June 1980 - September 1980.

Study Area 1 (Figures 2 and 3) - Area was fenced off to cattle and exhibited little damage typically associated with livestock.

Spring 4	-	Consisted of primary spring approximately 5 m in diameter with secondary pool associated with it. Bottom was covered with thick mats of Chara and filamentous algae in deeper sections. Average depth was .3-1 m. Noticeable outflow (<.1 cfs) to Pond 2 in June and September.
Spring 5	-	Springhead to Pond 2. Springhead approximately 1 m in diameter mostly overgrown with vegetation. Depth .3-.6 m. Connected with Pond 2 via definite narrow channel .3-1.5 m across. Definite flow noted but less than 0.1 cfs June through September.
Spring 6	-	Isolated springhead with no surface outlet dimensions, approximately 1.3 m x 2 m. Average depth 1 m with some deeper holes. Contains ledges below water's surface which made seining very difficult.
Spring 7	-	Small spring approximately .6 x 1 m, feeding a small pool. Spring choked with algae and Chara in June and July, only algae was present in August and September.
Spring 8	-	Isolated springhead with no surface outlet. Dimensions 1.5 m x 4 m. Depth 1-1.5 m at one end with hole deeper than 1.5 m shelving up to approximately 0.1 m at opposite end. Chara and filamentous algae in shallow end.
Spring 9	-	Very small, 0.6 m in diameter. Choked with filamentous algae.
Pond 1	-	Large body of open water. Surface area approximately 0.75 hectare. One side located within Study Area 1. Depth 0.2-0.6 m. Bottom completely covered in thick mats of Chara during June. Chara decreased and pond was dry by August; some water present again in September.
Pond 2	-	Dimensions approximately 30 m x 15 m. Depth 0.3-0.6 m. Bottom covered with thick mats of Chara in June; noticeably less in July, August, and September. Separated from Pond 3 by intrusion of wetland meadow into basin. Fed by Spring 5.

Table 1. Continued

Pond 3	-	Dimensions approximately 25 m x 15 m. Depth 0.3-1 m. Bottom covered by thick mats of Chara in June; substantial reduction in July, August, and September. Separated from Pond 2 and Pond 3 by intrusions of wetland meadows.
Pond 4	-	Dimensions approximately 25 m x 10 m. Depth and vegetation similar to Ponds 2 and 3.
Pond 5	-	Dimensions 2 m x 3 m. Choked with Chara except for two 0.5-m deep holes.
Pond 6	-	1 m x 2 m, shallow relatively free of Chara and other vegetation. Dry from July through September.
Pond 7	-	1 m diameter. Very shallow, depth 25 cm. Dry July-September.
Pond 8	-	2 m diameter; shallow. Dry July-September.
Pond 9	-	3 m x 1 m. Shallow; little vegetation. Dry July-September.
Pond 10	-	Similar to Pond 9 but smaller. Dry July-September.
Pond 11	-	1 m diameter; shallow. Dry in July and August, some water in September.
Pond 12	-	Large pond 30 m across. Depth 0.3-1 m. Bottom covered with thick mats of Chara in June; less Chara present in July through September.
Pond 13	-	3 m x 1 m; shallow. Some Chara and algae present. Dry July-September.
Pond 14	-	3-1/2 m x 1 m; shallow. Bottom wetland meadow. Dry in July-September.
Pond 15	-	Crescent shaped pond approximately 3 m across and 15 m long; shallow. Bottom wetland meadow, Chara and algae. Dry July-September.
Pond 16	-	Similar to Pond 15, but smaller; dry July-September.
Spring 10	-	Dimensions approximately 8 m x 3 m, maximum depth 1.5 m. Connected with a marsh area via long narrow channel. Similar in many respects to Spring 1.

Table 1. Continued

Study Area 2 - Spring 1 and locale (Figure 2) was not fenced and consequently exhibited extensive bank damage and erosion around springhead due to livestock usage.		
Spring 1	-	Dimensions approximately 15 m x 10 m. Maximum depth 2.5 m. Vertical sides with some limited shallow shelves along sides with assessory spring feeding it from the southwest. Main spring with channel 30-40 m long flowing into marsh area.
Spring 2	-	2 to 2.5 m in diameter. Depth 1-1/2 m. Limited surface outflow through bullrushes along one side. Located in south end of marsh (see Figure 1).

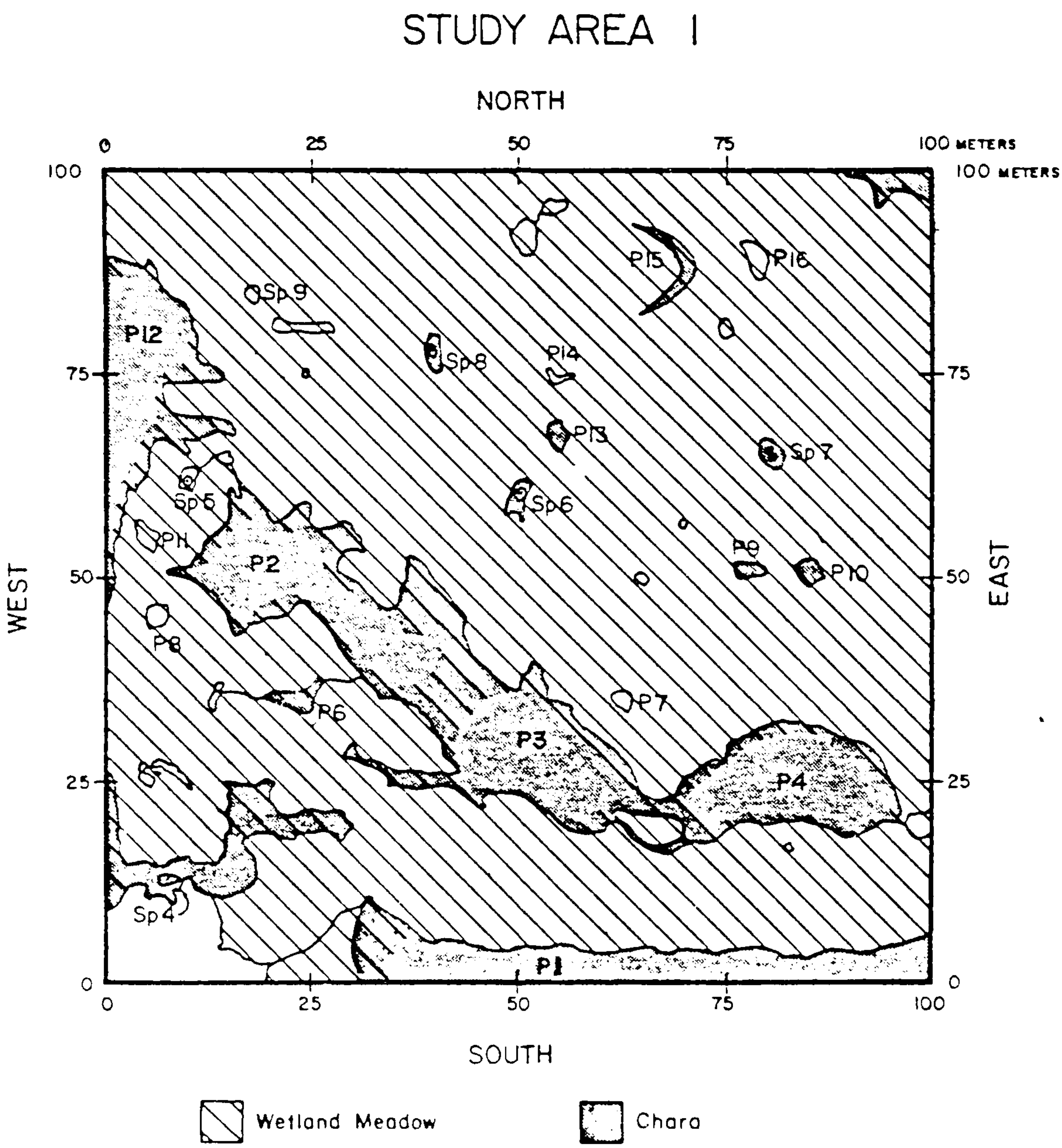

Figure 3. Pond and spring designations for Study Area 1 with vegetation types.

MATERIALS AND METHODS

General

The Leland Harris complex was reviewed during a field reconnaissance in June 1980. This review was used to set up study sites, familiarize the crew with the area and determine field sampling procedures. Field samples were taken on June 16-21, July 14-19, August 18-22, and September 15-19, 1980.

Mapping

Study Areas 1 and 2 were each mapped once during the study by laying out one hectare square grids with north-south transects 5 meters apart and points every 5 meters along the transect. Vegetation, elevation using a level and stadia rod, and landform were recorded at each 5-meter point. Elevations were recorded relative to a head stake.

Water Quality

Water samples were analyzed according to Standard Methods (APHA et al., 1973). Field conductivity and dissolved oxygen were measured with a YSI model 33 S-C-T meter and model 54A oxygen meter. Field pH measurements were made with an Analytical Measurements model 107 meter. Total hardness, total alkalinity, and chlorides were measured using titration techniques; nitrate, sulphate, and turbidity were measured spectrophotometrically with a Bausch and Lomb mini-spectrophotometer.

AD-A149 908 DEPLOYMENT AREA SELECTION AND LAND WITHDRAWAL/ACQUISITION M-X/MPS (M-X/MU..(U) HENNINGSON DURHAM AND RICHARDSON SANTA BARBARA CA 02 OCT 81 4/5

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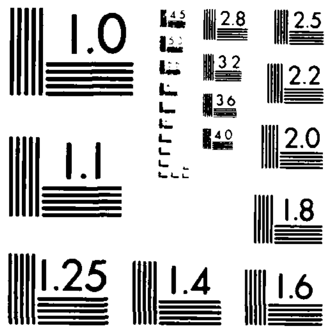


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

Water levels at Springs 1 and 4 were measured during each sample period by staff gages emplaced in the springheads. Gages were not set to a standard depth in each spring and readings thus measure only the relative fluctuations of water levels for each spring.

Phytoplankton - Periphyton

Duplicate whole water phytoplankton samples were collected in Springs 1 and 4 with a Van Dorn water bottle. Samples were preserved with Lugols solution and cupric sulfate, then kept in the dark until analyzed.

Periphyton samples were taken from different substrates and preserved in Lugols solution and cupric sulfate and also kept in the dark until analyzed. Analyses were done by Al Mahood, an algal specialist, using the following methodologies.

Periphyton

A portion of one aliquot of the sample was transferred to a 1.3 ml capacity settling chamber. Analysis of the green and blue-green algae was made under appropriate magnification using an Olympus IMT inverted microscope. Replicate samples were examined to determine 90% of the species. The number of replicates may vary with the community or number of dominants.

To determine the diatom community structure, a second aliquot was passed through a series of washings with distilled water. After removal of salts and colloidal material, an incinerated strew slide was prepared (mounted in Hyrax). Identification at 1000X was determined for 90% of the species. A minimum of 400 cells per slide was examined. (For the first samples, 5 aliquots were examined to better establish a primary list.)

Further cleaning with hydrogen peroxide, potassium permanganate and oxalic acid is continuing to assist in identification of the more difficult species.

Phytoplankton

An aliquot of the plankton samples was prepared for incineration to establish a species list of the diatoms prior to chamber counts with the inverted microscope.

Special preparation of the plankton aliquot (diatoms, green and bluegreen algae) was required. The sample was acidified by the addition of 2 to 4 drops of HCl/250 ml of sample in order to remove the $CaCO_3$ precipitate. Care was taken to minimize damage to the algae. After the sample had been acidified, a 75 ml aliquot was settled in a chamber. Identification of species was determined using an Olympus IMT inverted microscope at 1000X. Calculations to determine cells/ml were based on the following formula taken from Slack et al. (1973):

$$\frac{\text{Area of chamber mm}^2}{\text{Area counted mm}^2} \cdot \frac{\text{Total cell count x Vol. of chamber in ml.}}{\text{Vol. of original sample x 1 ml.}}$$

Zooplankton

Duplicate zooplankton samples were collected from open water areas with a Van Dorn water bottle. Fifteen liters of water were strained through a 64 mm mesh bucket to obtain a concentrated sample for analysis. Additional zooplankton were sampled by short (<3 m) tows with a 64 u mesh plankton net.

Species diversity values for invertebrate and plankton populations were calculated using the Shannon-Weaver species diversity index which can be expressed as:

$$\bar{d} = - \Sigma \, (Ni/N) \log_2 Ni/N$$

where: $\bar{d}$ = diversity

Ni = number of individuals in the i^{th} species

N = total number of all species.

Actual computation of values was accomplished using the machine formula:

$$\bar{d} = \frac{C}{N} (N \log_{10} N - \Sigma \, Ni \log_{10} Ni)^1$$

where: C = 3.322

N = total number of individuals

Ni = total number of individuals in the i^{th} species.

[1]EPA 1973.

Macroinvertebrates

Four replicate samples of macroinvertebrates were taken with a 232 cm^2 Ponar dredge in each selected habitat type in Springs 1 and 4. Intensity of macroinvertebrate sampling varied between the June-July and August-September sampling periods in Springs 1 and 4. During June and July, four habitat types were sampled in Spring 4; *Chara* in the open water areas of the spring, wetland meadow consisting mostly of sedges which intruded into the edges of the spring, filamentous green algae clumps usually associated with the actual entry point of spring water, and a flowing channel outlet. Habitat sampled in Spring 1 included only the shallow shelf areas of the spring. During August-September sampling periods, emphasis in invertebrate sampling was shifted from Spring 4 to Spring 1. *Chara* was the only habitat sampled in Spring 4. Four habitat types were sampled from Spring 1 and its associated areas. These included the shallow shelf area, the deep bottom area composed of a peat substrate, the outflow channel approximately 35 meters below the springhead and the middle arm of the marsh below Spring 1.

Samples were packaged in whirl-pak bags and preserved with 90% ethyl alcohol before transportation to the BIO/WEST invertebrate laboratory for analysis.

Aquatic invertebrates were identified to the lowest practical taxonomic level using a variety of references, which included Menke

1979, Merritt and Cummins 1978, Pennack 1978, Edmundson 1976, Mason 1973, Edmondson 1959, Usinger 1956, Needham and Westfall 1954, and Hungerford 1948. Chironomidae larvae were identified and sent to Dr. J. E. Sublette at the University of Eastern New Mexico, a recognized authority on chironomid taxonomy, for verification.

Results from the four benthic samples from each habitat type were pooled to obtain a mean density per taxa. Mean density was also computed for the total sample.

Fish

Collection

Fish collection techniques included use of a 15-foot seine with 1/8-inch mesh and baited minnow traps lined with 1.5 mm mesh netting. Fish were identified, enumerated and measured in sufficient numbers to provide length-frequency data. A minimum of 10 Utah chubs were collected and immediately killed and preserved in 10 percent formalin each month for stomach analysis. Ten to twenty least chubs were also collected for stomach analysis in August and September. Larger Utah chubs in selected springs were tagged with numbered fingerling tags to record movements and document growth. Qualitative visual observations of relative fish abundance were made by examining plots approximately .1 m^2 in size and noting the abundance of fish. Numerous fish were also marked by fin clips in order to estimate populations by mark and recapture methods.

The formula used for estimating population size was taken from Ricker (1971) and can be expressed as:

$$N = \frac{mc}{r}$$

where: N = Estimate of total number of fish in the population

m = Total number of fish marked in the population

c = Number of fish in the sample

r = Number of marked fish recaptured in the sample.

The standard error of N (S.E. [N]) is then estimated by the formula:

$$S.E.\ (N) = N \sqrt{\frac{(N-m)\ (N-c)}{mc\ (N-1)}}$$

Stomach Analysis

Fish preserved in formalin for stomach analysis were first washed in tap water, then preserved in 40 percent isopropyl alcohol before dissection. Each fish was opened ventrally and all viscera removed. The anterior section of the stomach was then separated from the remainder of the intestinal tract. Stomach fullness was estimated visually. Food items were sorted and identified to the lowest taxa possible under an 80X Olympus stereo microscope and the volume that each taxa represented of the total mass visually estimated with the aid of a calibrated ocular grid. In the case of fish between 11 mm and 30 to 40 mm, and when stomach contents were composed primarily of algae and/or detritus, smears of stomach contents were made on microscope slides and examined under an Olympus stereo-compound microscope (max. mag. 1000X). All other manipulations were the same as in larger fish.

RESULTS

Vegetation and Mapping

Vegetation within Study Area 1 was primarily composed of *Scirpus*, *Juncus*, *Carex*, *Eleocharis*, *Distichlis*, and *Chara* (Table 2).

There were three major vegetation types: the open water type composed almost totally of *Chara*; the upland, dry meadow composed primarily of *Carex occidentalis*; and the wetland meadow which comprised most of the study area and was dominated by *Scirpus*, *Juncus*, *Eleocharis*, and *Distichlis*. Most of the study area was wetland meadow and the upland meadow type was composed of small, scattered clumps within the wetland meadow. In the springs themselves, clumps of filamentous green algae, primarily *Spirogyra* and *Mougeotia*, were also common. Small scale patterns of vegetation (<25 m^2) were not revealed due to the coarseness of the method employed.

Figure 3 shows the vegetation in relation to the ponds and springs of Study Area 1. Figure 4 delineates the vertical profiles of 3 representative cross-sections of Study Area 1 with water levels present on June 17 shaded in. Elevations were all relative to a permanent headstake.

Vegetation in Study Area 2 (Spring 1 and locale) was very similar to the first study area with the exception that bullrushes were present in some spots. Study Area 2 also had a larger percentage of high ground than Study Area 1 (Figure 5).

Table 2. Species list of vegetation, Study Area 1.

Sesuvium verrucosum Raf
Elymus triticoides Buckley
Triglochin maritima L
Scripus pungens Vahl. (D)[1]
Juncus balticus Willd (D)
Carex occidentalis Bailey (D)
Eleocharis palustris (L) Rts. (D)
Distichlis (D) sp.
Chara (D) sp.
Potentilla sp.
Iris sp.

[1]Dominant vegetation types.

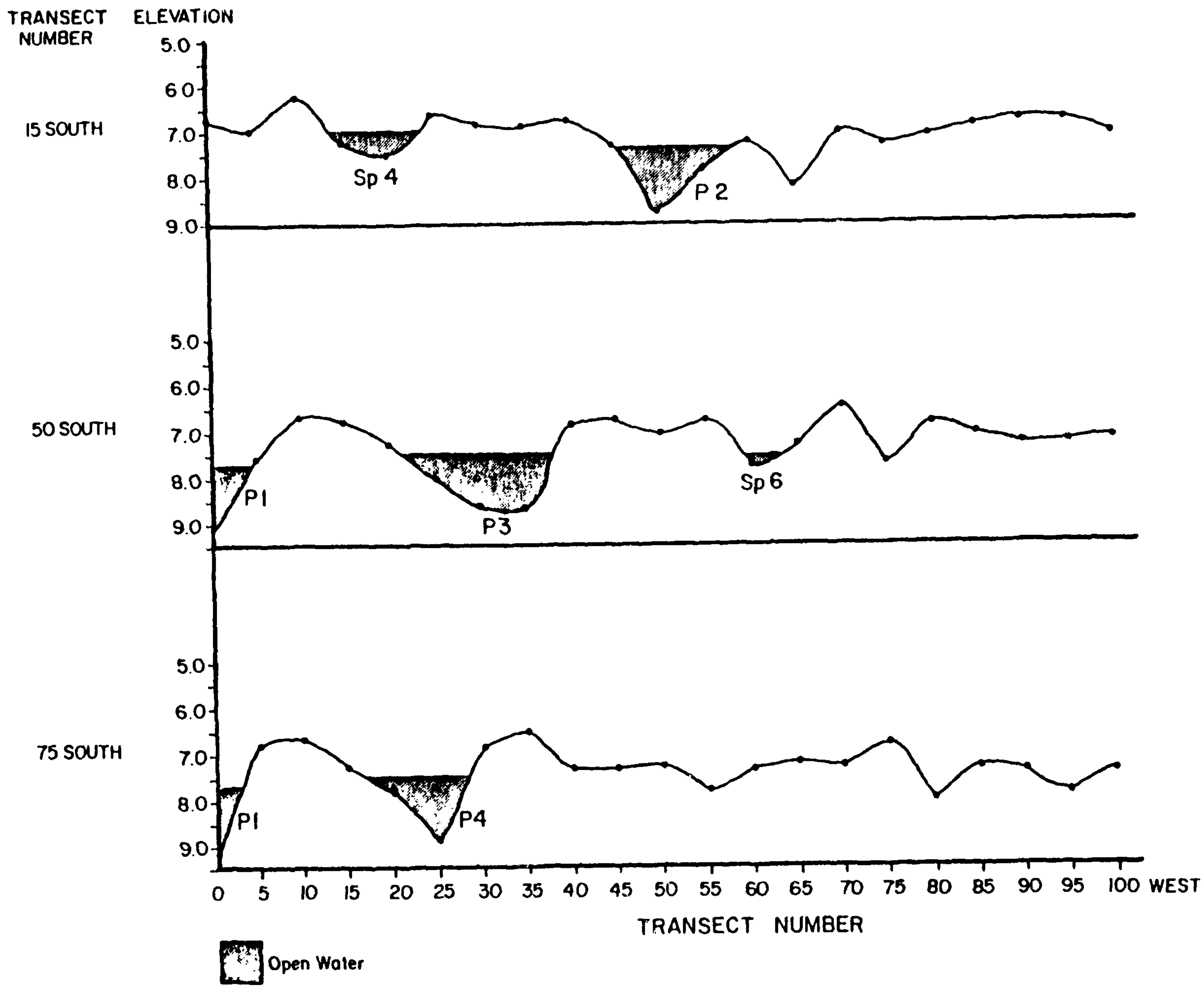


Figure 4. Three cross-sections of Study Area 1 showing representative vertical profiles.

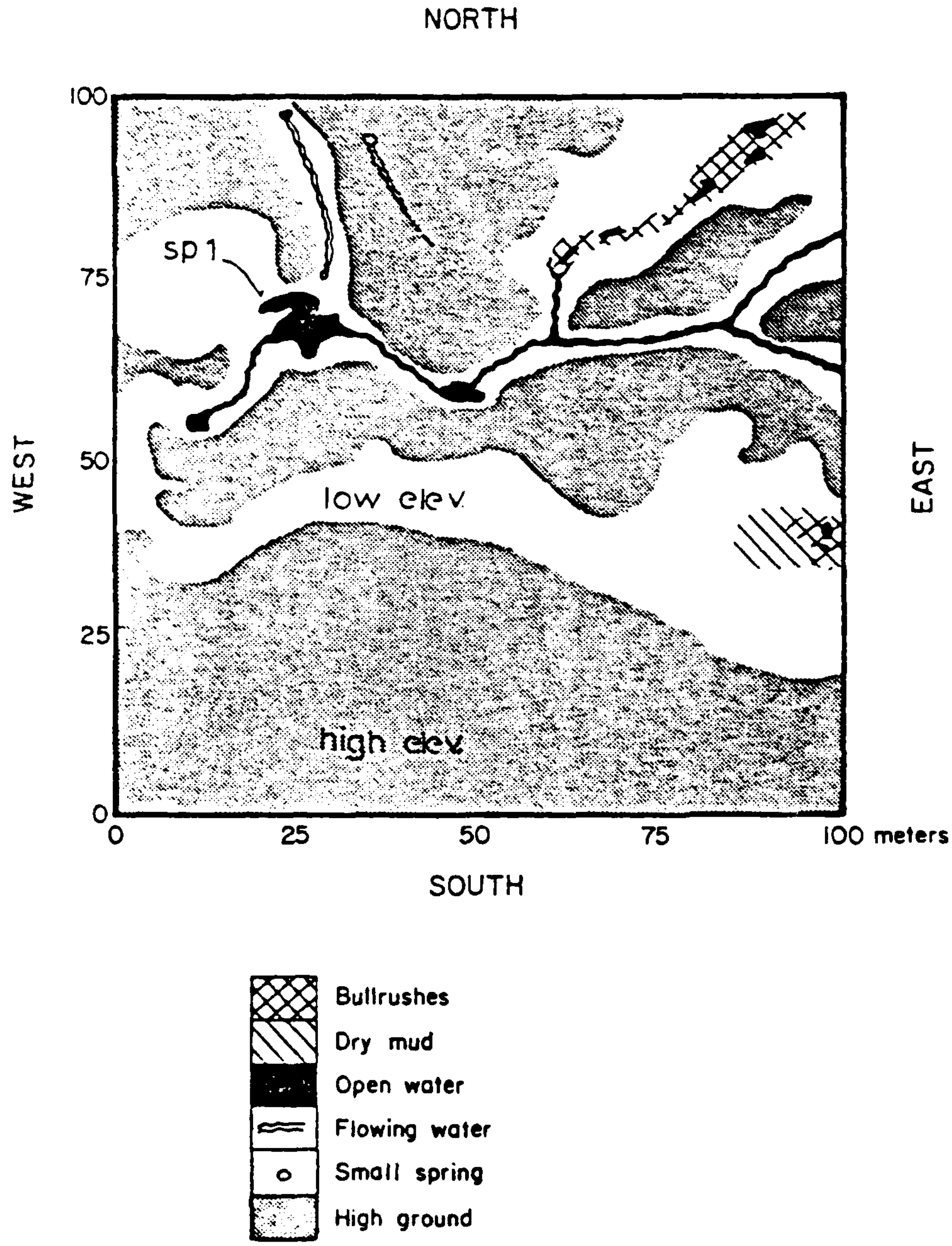


Figure 5. Map of Study Area 2.

Water Quality

Water levels for Springs 1 and 4 as measured by staff gages are presented in Table 3. Water chemistry data for Springs 1 and 4 are summarized in Table 4. Additional water quality data were collected from a variety of springs and ponds in Study Area 1 (Table 5) and from trap locations in and around Spring 1 (Tables 24 and 25). Vertical and diurnal profiles of temperature and dissolved oxygen generated for selected sites in Study Area 1 in July are shown in Figures 6, 7, and 8.

Table 3. Water levels, Springs 1 and 4, June-September 1980.

	Spring 1	Spring 4
June 1980	57.20 cm	54.46 cm
July	48.90 cm	52.37 cm
August	48.26 cm	53.04 cm
September	50.16 cm	53.04 cm

In general, the springs exhibited cool, stable temperatures, relatively low, stable dissolved oxygen values, and low conductivities. Areas such as Spring 1, its channel and marsh below often exhibited distinct water quality gradients, particularly in the afternoon when

Table 4. Selected water quality parameters for Springs 1 and 4, June - September 1980.

Station	Date	Time	Temp. (°C)	Turbidity (FTU)	pH	Dissolved oxygen (mg/l)	Conductivity (umhos/cm)	Total alkalinity (mg/l $CaCO_3$)	Total hardness (mg/l)	Chlorides (mg/l)	Sulphate (mg/l)	Nitrate (mg/l)
Sp. 4	6/17/80	1500	23.0	0	8.4	16.5	490	-[2]	260	30	44	0
Sp. 4	7/15/80	1410	15.0	0	8.6	13.0	430	220	180	30	18	0.4
Sp. 4	8/19/80	1405	15.2	0	8.1	5.8	448	220	200	20	34	0.4
Sp. 4	9/16/80	1400	19.0	5	7.1	13.2	900	290	270	70	85	trace
Sp. 1	6/20/80	0900	13.5	9	7.9	8.2	510	-[2]	180	30	24	2.0
Sp. 1	7/17/80	0915	13.5	3	8.0	6.0	375	200	180	30	26	0.4
Sp. 1	8/20/80	1430	17.0	2	7.6	6.6	410	200	150	30	20	0.3
Sp. 1	9/17/80	1210	15.0	12	7.7	7.2	440	200	180	40	30	0.7

[1]Measurements and samples taken at 3 cm depth.

[2]Data not taken.

Table 5. Temperature and conductivity for 21 sites in Study Area 1, June - September 1980.

		June			July			August			September		
		Temp. (°C)	Cond.	Time	Temp. (C°)	Cond.	Time	Temp. (°C)	Cond.	Time	Temp. (°C)	Cond.	Time
Spring 4	surf.	18.0	515	1130	22.0	430	1410	16.0	440	1405	19.0	900	1400
	bot.	12.0	515		15.0			15.0	-		15.0	-	
Spring 4	surf.	20.0	470	1530	15.0	380	1500	14.5	460	1010	15.0	480	1425
	bot.	15.0			15.0			14.5			-		
Spring 6	surf.	15.0	450	1530	25.0	500	1500	17.0	415	1225	19.5	380	1435
	bot.	14.0	420		15.5	450		12.5			-	-	
Spring 7	surf.	24.0	520	1540	27.0	690	1505	15.0	405	1730	-	-	-
	bot.	17.0			18.0	900		12.0					
Spring 8	surf.	23.0	450	1600	27.0	600	1505	19.0	405	1725	20.0	475	1430
	bot.	15.0			20.0	600		-	-		-	-	
Spring 9	surf.	16.0	410	1800	-	-	-	-	-	-	-	-	-
	bot.	16.0											
Pond 1		17.0	540	1100	28.0	1,075	1530	--------Dry--------			25.0	1,950	1400
Pond 2		18.5	750	1215	31.0	700	1530	17.0	680	1050	28.0	1,000	1405
Pond 3		18.0	1,300	1200	30.0	1,310	1530	-	-	-	25.0	1,450	1445
Pond 4		22.0	1,700	1300	25.0	1,960	1531	-	-	-	25.0	1,450	1450
Pond 5		20.0	1,925	1330	--------Dry--------			--------Dry--------			--------Dry--------		

Table 5. Continued

		June			July			August			September		
		Temp. (°C)	Cond.	Time	Temp. (°C)	Cond.	Time	Temp. (°C)	Cond.	Time	Temp. (°C)	Cond.	Time
Pond 6	surf. bot.	22.0 26.0	2,800	1330	--------Dry--------			--------Dry--------			--------Dry--------		
Pond 8		32.0	28,000	1400	--------Dry--------			--------Dry--------			--------Dry--------		
Pond 9		26.0	11,000	1430	--------Dry--------			--------Dry--------			--------Dry--------		
Pond 10		26.0	7,000	1430	--------Dry--------			--------Dry--------			--------Dry--------		
Pond 11		34.0	5,000	1500	--------Dry--------			--------Dry--------			28.5	22,000	1505
Pond 12		27.0	1,300	1730	24.5	1,800	1540	-	-	-	25.0	3,400	1500
Pond 13	surf. bot.	31.0 29.0	2,500	1600	--------Dry--------			--------Dry--------			--------Dry--------		
Pond 14		25.0	4,250	1730	--------Dry--------			--------Dry--------			--------Dry--------		
Pond 15		29.0	2,300	1800	--------Dry--------			--------Dry--------			--------Dry--------		
Pond 16		30.0	6,200	1815	--------Dry--------			--------Dry--------			--------Dry--------		

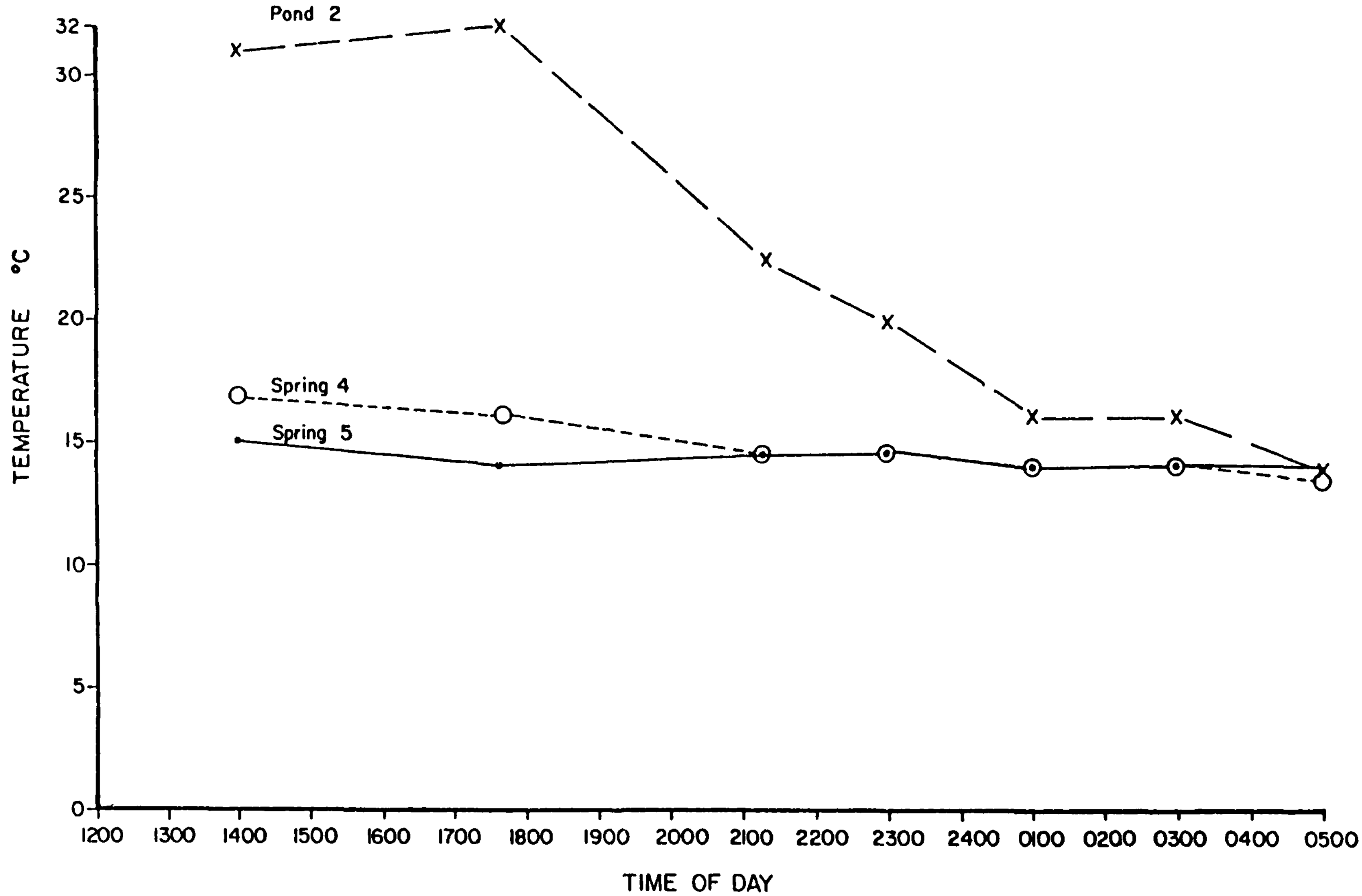


Figure 6. Temperature fluctuations for 3 sites in Study Area 1 between 1200 July 15 and 0500 July 16, 1980.

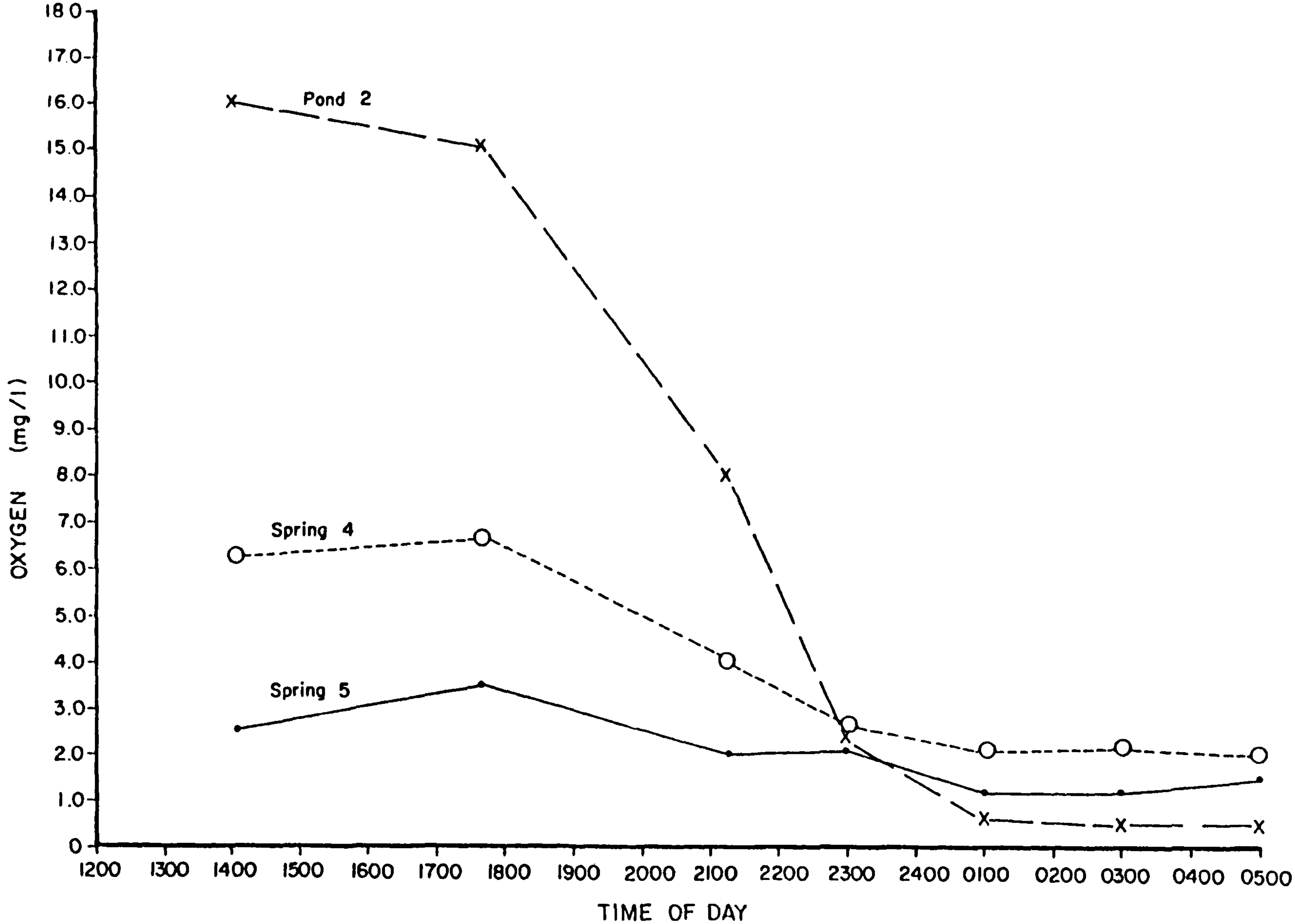


Figure 7. Dissolved oxygen fluctuation for 3 sites in Study Area 1 between 1200 July 15 and 0500 July 16, 1980.

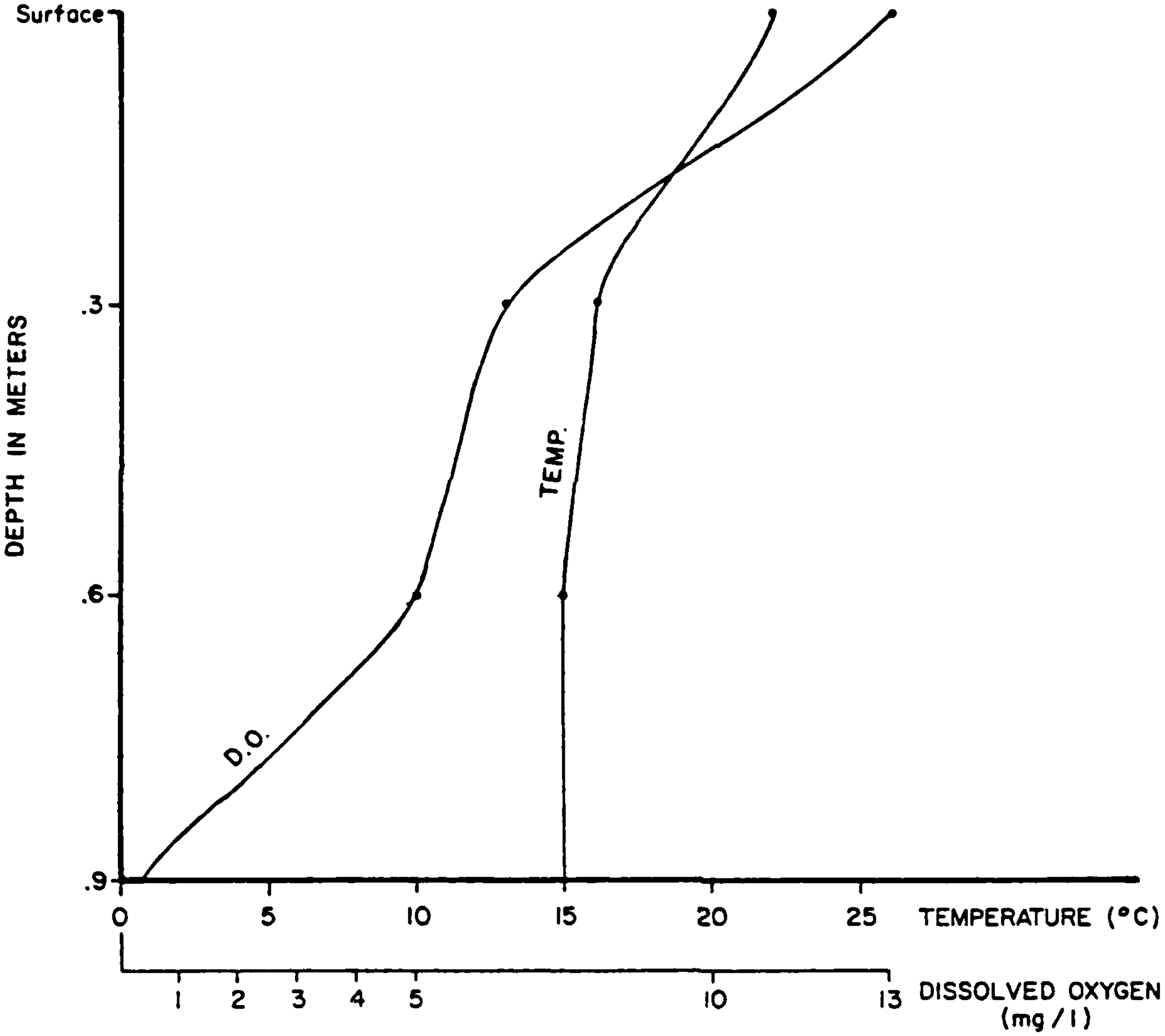


Figure 8. Vertical profile of dissolved oxygen and temperature in Spring 4 at 1410, July 15, 1980.

the marsh displayed higher temperatures, conductivity, pH, and dissolved oxygen than the springhead. Channel values, though transitional, were more similar to the springhead than marsh.

Phytoplankton-Periphyton

Total phytoplankton densities varied widely from a low of 17.12 cells/ml in Spring 4 in June to a high of 858.84 cells/ml in Spring 4 in August. Population density trends were the same for Spring 1 and 4, with low populations in June, increasing to a peak in August, after which densities decreased to almost the levels observed in June (Figure 9).

Species composition of the phytoplankton was dominated by diatoms during each sample period, except for the August sample in which a bloom of *Carteria* sp. (Chlorophyta) and *Cryptomonas* sp. (Chlorophyta) occurred in Spring 4 (Table 6). Common and abundant species of diatoms included *Achnanthes minutissima* (Kutz) v. *minutissima*, *Fragillaria* spp., *Nitzschia paleacea* (Grunow), *Synedra radians* (Kutz) *radians*, *Synedra ulna* (Nitz), and *Gomphonema* spp. Chlorophyta and Cyanophyta were not common except at Spring 4 in August. Species diversity values calculated for the phytoplankton of Springs 1 and 4 are presented in Table 7.

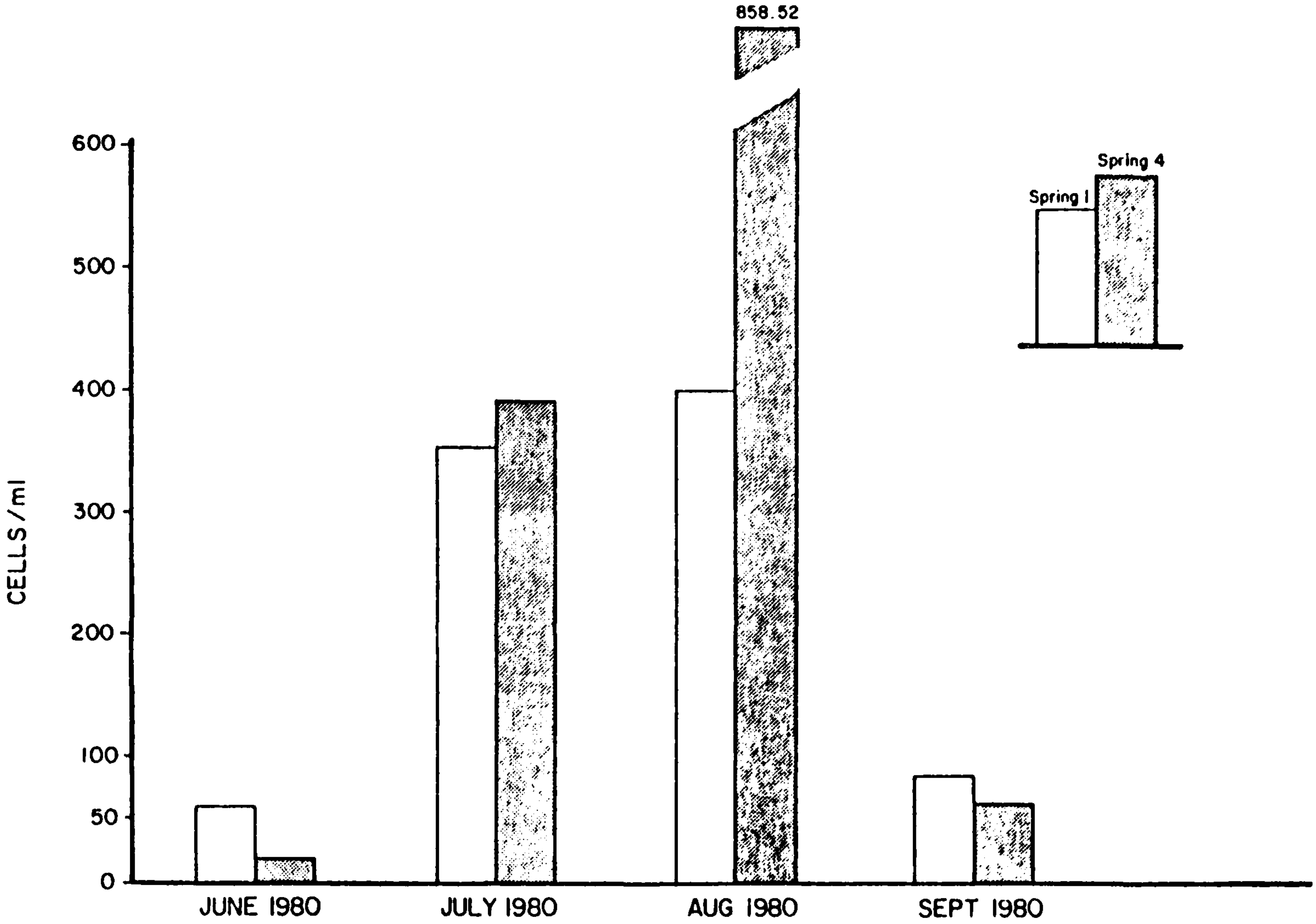


Figure 9. Mean density (cells/ml) of total phytoplankton, June - September 1980.

Table 6. Mean phytoplankton density (cells/ml) at Leland Harris Springs 1 and 4, June-September 1980.

Species	Spring 1				Spring 4			
	6/20/80	7/17/80	8/20/80	9/17/80	6/17/80	7/15/80	8/19/80	9/16/80
Clorophyta								
Ankistrodesmus						4.55	2.58	0.73
Carteria							517.32	
Chlamydomonas							2.58	0.54
Cladophora							4.16	
Closterium					0.01			
Cryptomonas				0.53			114.34	6.04
Gleocystis							2.58	0.31
Kirckneriella							5.16	
Mougeotia		0.34		1.06	0.22	1.33	2.58	0.54
Scenedesmus								0.54
Spirogyra				0.53	0.11			1.75
Ulothrix					0.22			

Table 6. Continued

Species	Spring 1				Spring 4			
	6/20/80	7/17/80	8/20/80	9/17/80	6/17/80	7/15/80	8/19/80	9/16/80
Euglenophyta								
Euglena							4.16	7.33
Bacillariophyceae								
Amphora								0.39
Achnanthes spp.								
A. exigua Grunow				0.53				
A. lanceolata (Breb.) Grun. *lanceolata*		1.02	3.69					
A. minutissima (Kutz.) v. *minutissima*	0.41	26.46	72.04	7.69	0.19	16.68	16.44	3.08
Anomoeoneis spp.								1.15
Cocconeis spp.								
C. placentula v. *lineata* (Ehr.) Cleve		4.67	1.83	1.59		0.88		1.15
Cymbella spp.		19.18		0.82		8.16		0.31
C. affinis (Kutz.) v. *affinis*		4.98	46.58	7.89		1.37		

Table 6. Continued

Species	Spring 1				Spring 4			
	6/20/80	7/17/80	8/20/80	9/17/80	6/17/80	7/15/80	8/19/80	9/16/80
Bacillariophyceae (continued)								
C. cymbiformes Ag. v. cymbiformis	1.76	1.37			0.12	0.44		
C. mexicana (Ehr.) Cl. v. mexicana		0.34						
C. microcephala Grun. microcephala		5.58	1.83			0.88	7.74	0.77
C. minuta Hilse ex. Rhab. minuta		7.85		1.47				
Denticula spp.		3.64		1.0				3.08
D. tenuis Kutzing			13.28					
Diatoma spp.								
D. elongatum Ag.					0.44	0.44		
D. vulgare Bory		5.92				3.75		0.62
Epithemia spp.	0.13	13.70			0.24	7.66		
E. argus v. protracta A. Mayer		2.49	7.59					0.51

Table 6. Continued

Species	Spring 1				Spring 4			
	6/20/80	7/17/80	8/20/80	9/17/80	6/17/80	7/15/80	8/19/80	9/16/80
Bacillariophyceae (continued)								
_E_. _turgida_ (Ehr.) Kutzing						0.44		
Enrotia curvata (Kutz.) _largerst_ v. _curvata_	0.13				0.03			
Fragilaria spp.								
F. (Complex)	45.50	145.74	9.13	7.42	0.45	3.75		
_F_. _construens_ (Ehr.) Grunow v. _construens_	0.82		20.7	28.39				
_F_. _crotonensis_ Kitton					2.40	45.71		
_F_. _leptostauron_ v. _dubia_ (Grun.) Hustedt			10.62					
_F_. _pinnata_ (Ehr.) v. _pinnata_	0.21	7.60	7.62		0.30			
_F_. _vaucheriae_ (Kutz.) Peters v. _vaucheriae_			21.84					
_F_. _virescens_ Ralfs			5.20					
Gomphonema spp.	0.21	3.18	19.09	1.74	0.06		2.58	2.46

Table 6. Continued

Species	Spring 1				Spring 4			
	6/20/80	7/17/80	8/20/80	9/17/80	6/17/80	7/15/80	8/19/80	9/16/80
Bacillariophyceae (continued)								
G. intricatum (Kutz.) v. intricatum	0.27					1.37		
G. parvulum (Kutz.)	0.02		12.73	1.10				0.85
G. subclavatum			4.68					
G. truncatum v. capitatum (Ehr.) Patrick	0.27	2.83	1.20		0.26			0.51
Mastigloia spp.								
M. smithii Thwaites ex W. Smith smithii	0.35	2.74		1.41		1.37		0.54
Melosira spp.								
M. varians C.A. Ag.	0.67			1.59				
Navicula spp.	0.82	11.06	48.42	1.06	0.35	5.44	4.41	1.19
N. capitata Ehr. v. capitata			4.68					
N. cryptocephala Kutzing		1.24	2.49	0.53				

Table 6. Continued

Species	Spring 1				Spring 4			
	6/20/80	7/17/80	8/20/80	9/17/80	6/17/80	7/15/80	8/19/80	9/16/80
Bacillariophyceae (continued)								
N. pupula v. rectangularis (Greg.) Grunow		0.34		1.06				
N. radiosa (Kutz.) v. radiosa		2.49						
N. rhyncocephala Kutzing		0.34						
Neidium spp.		0.34						
Nitzschia spp.	0.27		2.39	2.59				0.62
N. acicularis W. Smith	0.14	3.74	1.56	1.59		19.88		1.62
N. frustulum (Kutz.) Grunow		5.58	1.61	0.53			2.58	
N. linearis W. Smith		8.62	1.20	1.06				
N. paleacea Grunow	0.06	32.38	59.87	5.22		9.50	2.58	7.52
N. sigmoidea (Ehr.) W. Smith					0.02	0.44		
Pinnularia spp.	0.16	1.72	0.83		0.10			0.81
P. major Kutzing								0.31

Table 6. Continued

Species	Spring 1				Spring 4			
	6/20/80	7/17/80	8/20/80	9/17/80	6/17/80	7/15/80	8/19/80	9/16/80
Bacillariophyceae (continued)								
Rhoicosphenia curvata (Kutz.) Grunow								0.31
Rhopalodia spp.								
R. gibba (Ehr.) O. Muller				0.41	0.74			
R. musculus (Kutz.) O. Muller v. *musculus*	0.14	1.24		0.53				
Synedra spp.			6.71					
S. radians (Kutz.) *radians*	3.05	16.38	6.84	2.03	7.58	161.93	38.57	6.26
S. ulna (Nitz.) Ehr.	1.50	8.19	4.98		1.98	83.61	7.74	
S. ulna v. *spathulifera* (Gron.) V.H.					0.08			
Cyanophyta								
Anabena					0.30			
Dactyococcopsis fascicularis Lermmerm						0.88		

Table 6. Continued

Species	Spring 1				Spring 4			
	6/20/80	7/17/80	8/20/80	9/17/80	6/17/80	7/15/80	8/19/80	9/16/80
Cyanophyta								
Lyngbya			0.83	0.74		4.03	59.62	0.54
Microcystis				1.59			14.56	1.54
Oscillatoria	0.13		1.20		0.92	8.22	46.56	9.82
Stichosiphon								0.62
Early forms				2.65				0.73
Total	57.29	353.29	403.26	86.35	17.12	392.71	858.84	65.09

Table 7. Shannon-Weaver species diversity indices for the phytoplankton communities in Springs 1 and 4, June-September 1980.

	6/80	7/80	8/80	9/80
Spring 1	1.54	3.68	3.52	3.14
Spring 4	2.88	2.82	2.72	3.74

Monthly periphyton species lists for Spring 4 (June-September) and Spring 1 (August and September) (Table 8) showed Achnanthes minutissima (Kutz) minutissima, Cymbella microcephala (Grunow) microcephala, Fragillaria spp., Nitzschia frustulum (Kutz), N. paleacea (Grunow), and Synedra radians (Kutz) radians to be among the most commonly occurring diatoms. Chara vulgaris Linnaeus and Spirogyra sp. were the most commonly occurring green algae. Blue-green algae were uncommon in the periphyton community.

Although quantitative periphyton samples were not taken, qualitative visual observations indicated that in most cases the periphyton community in shallow areas of springs and ponds was dominated by large beds of Chara and clumps of Spirogyra.

Known ecological preferences for diatom species present in the phytoplankton and periphyton is listed in Table 9. Most species had transcontinental distributions in North America, were alkaphilous and

Table 8. Occurrence of periphyton species in Leland Harris Spring No. 4, June-September 1980, and Spring No. 1, August and September 1980.

Species	Spring 4				Spring 1	
	6/80	7/80	8/80	9/80	8/80	9/80
Chlorophyta						
Chara vulgaris Linnaeus	X	X	X		X	X
Cladophora						X
Gleocystis		X				
Mougeotia	X					
Scenedesmus		X				
Spirogyra	X	X	X	X	X	
Ulothrix	X					X
Bacillariophyceae						
Achnanthes spp.					X	X
A. exigua Grun _exigua_	X		X			
A. lanceolata (Breb.) Grun. _lanceolata_	X				X	X
A. minutissima (Kutz) v. _minutissima_	X	X	X	X	X	
Amphora spp.				X		X
A. ovalis (Kutz) _Kutzing_ v. _ovalis_		X				
A. perpusilla (Grun.) Grunow			X			
Anomoeoneis spp.	X					
A. sphaerophora (Ehr.) Pfitz v. _sphaerophora_		X				

Table 8. Continued

Species	Spring 4				Spring 1	
	6/80	7/80	8/80	9/80	8/80	9/80
Bacillariophyceae (continued)						
A. sphaerophora (Kutz.) Pf.						X
Cocconeis spp.						
C. placentula v. linesta (Ehr.) Cleve	X	X	X	X	X	
Cymbella spp.						
C. affinis Kutz. v. *affinis*	X	X	X		X	X
C. cistula (Ehr.) Kirchn			X			
C. cymbiformis Ag. v. *cymbiformis*	X	X	X			
C. mexicana (Ehr.) Cl. v. *mexicana*	X	X		X		
C. microcephala Grunow *microcephala*	X	X	X	X	X	X
C. minuta Hilse ex Rhab. *minuta*		X	X	X	X	X
C. tumida (Breb. ex Kutz.) V.H. v. *tumida*		X	X			
Denticula spp.		X	X	X	X	X
Diatoma spp.						
D. elongatum Ag.	X	X				
Diploneis spp.			X			X
Epithemia spp.						
E. argus v. *protracta* A. Mayer	X	X	X	X	X	X
E. turgida (Ehr.) Kutz.	X	X				

Table 8. Continued

Species	Spring 4 6/80	Spring 4 7/80	Spring 4 8/80	Spring 4 9/80	Spring 1 8/80	Spring 1 9/80
Bacillariophyceae (continued)						
Eunotia spp.						
E. curvata (Kutz.) Largerst. v. curvata	X					
Fragilaria spp.		X				
F. brevistrata v. inflata (Pant.) Hust.	X	X	X	X	X	
F. capucina v. mesolepta Rabh.	X	X				
F. construens (Ehr.) Grun. construens	X	X	X	X	X	X
F. construens v. binodis (Ehr.) Grunow			X			
F. crotonensis Kitton	X	X			X	
F. pinnata Ehr. V. pinnata	X	X	X	X	X	X
F. vaucheriae (Kutz) peters			X			X
Gomphonema spp.					X	
G. acuminata v. pulsilla Grun.	X					
G. intricatum Kutz. v. intricatum	X	X	X	X	X	
G. parvulum Kutzing			X	X	X	X
G. truncatum v. capitatum (Ehr.) Patr.	X	X	X	X	X	X
Mastigloia spp.						

Table 8. Continued

Species	Spring 4				Spring 1	
	6/80	7/80	8/80	9/80	8/80	9/80
Bacillariophyceae (continued)						
M. smithii Thwaites ex. W. Sm. *smithii*	X	X		X	X	X
Melosira spp.					X	
M. ambigua (Grun.) D. Muller	X					
M. varians C. A. Ag.	X					
Navicula spp.	X					X
N. antigua Cleve						X
N. cryptocephala Kutzing		X	X			
N. cuspidata Kutzing		X				
N. halophila (Grun.) Cl. v. *halophila*	X		X			
N. halophila v. *teniuro* Hustedt					X	
N. ilopangoensis Hustedt v. *ilopangoensis*			X			
N. menisculus Schumann	X					
N. mutica Kutz. *mutica*	X	X			X	
N. peregrina (Ehr.) Kutzina v. *peregrina*		X				
N. pupula v. *rectangularis* (Greg.) Grun.	X	X				
N. radiosa Kutzing v. *radiosa*		X	X			
N. secreta v. *apiculata* Patrick			X			

Table 8. Continued

Species	Spring 4				Spring 1	
	6/80	7/80	8/80	9/80	8/80	9/80
Bacillariophyceae (con' inued)						
Neidium spp.					X	
N. iridis v. amphigomphus (Ehr.) A. Mayer	X	X				
Nitzschia spp.					X	X
N. acicularis W. Smith	X					X
N. amphibia Grunow	X					
N. frustulum (Kutz.) Grunow	X	X	X	X	X	X
N. linearis W. Smith		X	X			
N. paleacea Grunow	X	X	X	X		X
N. sigmoidea (Ehr.) W. Sm.	X	X				
N. trublionella Hantzschia		X	X			
Pinnularia spp.	X	X			X	
P. major (Kutz.) Cleve					X	
P. viridis (Nitz.) Ehr. v. viridis	X					
Rhoicosphenia spp.						
R. curvata (Kutz.) Grunow						X
Rhopalodia spp.						
R. gibba (Ehr.) O. Muller	X	X	X	X	X	X
R. gibberula (Ehr.) O. Muller			X			
R. musculus (Kutz.) O. v. musculus	X	X			X	X

Table 8. Continued

Species	Spring 4 6/80	Spring 4 7/80	Spring 4 8/80	Spring 4 9/80	Spring 1 8/80	Spring 1 9/80
Bacillariophyceae (continued)						
Stauroneis spp.						
S. phoenicentron v. *gracilis* (Ehr.) Hust.	X	X				
Synedra spp.						
S. radians (Kutz.) *radians*	X	X	X	X	X	X
S. ulna (Nitz.) Ehr.	X	X	X		X	X
S. ulna v. *spathulifera* (Grun.) V.H.	X	X	X			
Chrysomonad cysts			X	X	X	X
Cyanophyta						
Nostoc		X				
Ocillatoria		X				

Table 9. U.S. distribution and preferred habitat conditions of selected diatoms.[1]

Species	Distribution in U.S.[2]	pH preference			Preferred salt conc.		Misc. ecological information
		Alkaline	Neutral	Acid	Oligohalobe	Mesohalobe	
Achnanthes lancedata (Breb) Grun. lanceolata	T	X	X				Tolerates wide range ecological cond.
A. minutissima (Kutz) v. minutissima	T	X	X	X			
Cymbella affinis (Kutz) v. affinis	T	X			X		Alkaphil of wide distribution in streams and lakes
C. cymbiformis Ag. v. cymbiformis	T						Lake form
C. mexicana (Ehr) Cl v. mexicana	N W	X					Usually found in hard waters.
C. microcephala Gronow microcephala	T	X			X		Tolerant of some Cl conc.
C. minuta Hilse ex Rabh minuta	T	X	X	X	X		Eurytopic[3]
Cocconeis placentula v. lineata Ehr (cleve)	T	X	X				Eurytopic[3]
Epithemia argus v. protracta A. Mayer	C						Reported only from a bog in U.S.
E. turgida (Ehr) Kutzing	T	X					Littoral species; tolerates relatively high cond.
Eunotia curvata (Kutz) largerst v. curvata	T	X	X	X	X		Sometimes in alkaline waters, usually acidic.
Fragilaria crotonensis Kitton	T						Plankton sp. widely distributed in mesotrophic waters.
F. pinnata (Ehr) v. pinnata	T						Widely distributed in fresh water.
Navicula cryptocephala Kutzing	T				X		Widely distributed in lakes, rivers and bogs; prefers water of moderate cond.
N. pupula v. rectangularis (Greg) Grunow	T	X			?		Has been found in salt bogs

Table 9. Continued

Species	Distribution in U.S.[2]	pH preference			Preferred salt conc.		Misc. ecological information
		Alkaline	Neutral	Acid	Oligohalobe	Mesohalobe	
N. radiosa Kutz v. radiosa	T	?	X		X		Eurytopic[3]
N. rhyncocephala	T				X		
Rhopalodia musculus Kutz	T	?					Seems to prefer waters with high cond.
R. mollure v. musculus							
Synedra radians (Kutz) v. radians	T	X					Sometimes found in water with fairly high cond.
Synedra ulna (Nitz) Ehr	T						Eurytopic[3]

[1] Based on Patrick and Reimer 1966, 1975, and Czarnecki and Blinn 1978.

[2] T - transcontinental dist.; N - northern; W - western; C - central.

[3] Eurytopic - tolerant of a wide range of physical-chem. conditions.

preferred waters of low to moderate salt concentrations though often tolerant of higher concentrations.

Zooplankton

No zooplankton were collected during any month in the open water with either a Van Dorn bottle or plankton net. However, *Simocephalus vetulus*, *Alona* sp., *Chydorus* sp., and *Cyclops vernalis* were found in qualitative samples of bottom debris and vegetation.

Macroinvertebrates

Over forty invertebrate taxa were collected from the Leland Harris area in quantitative and qualitative samples. Chironomidae (Diptera) and gastropods were typically the most abundant groups of invertebrates with amphipods being occasionally dominant (Figure 10).

Samples taken in the actual springheads indicated that Spring 4 sustained a higher density of macroinvertebrates than Spring 1. However, samples taken in channels below springs showed high densities in both areas (Tables 10 and 11). Highest recorded densities occurred in the outflow of Spring 1 in September. Lowest recorded densities occurred in the bottom of Spring 1 during August.

Species diversity values calculated from macroinvertebrate data on Springs 1 and 4 ranged from 0 to 3.72 (Table 12). Lowest values (0-2.01) were recorded from the bottom of Spring 1 and highest values (3.70-3.72) from *Chara* beds in Spring 4. Higher diversity values were

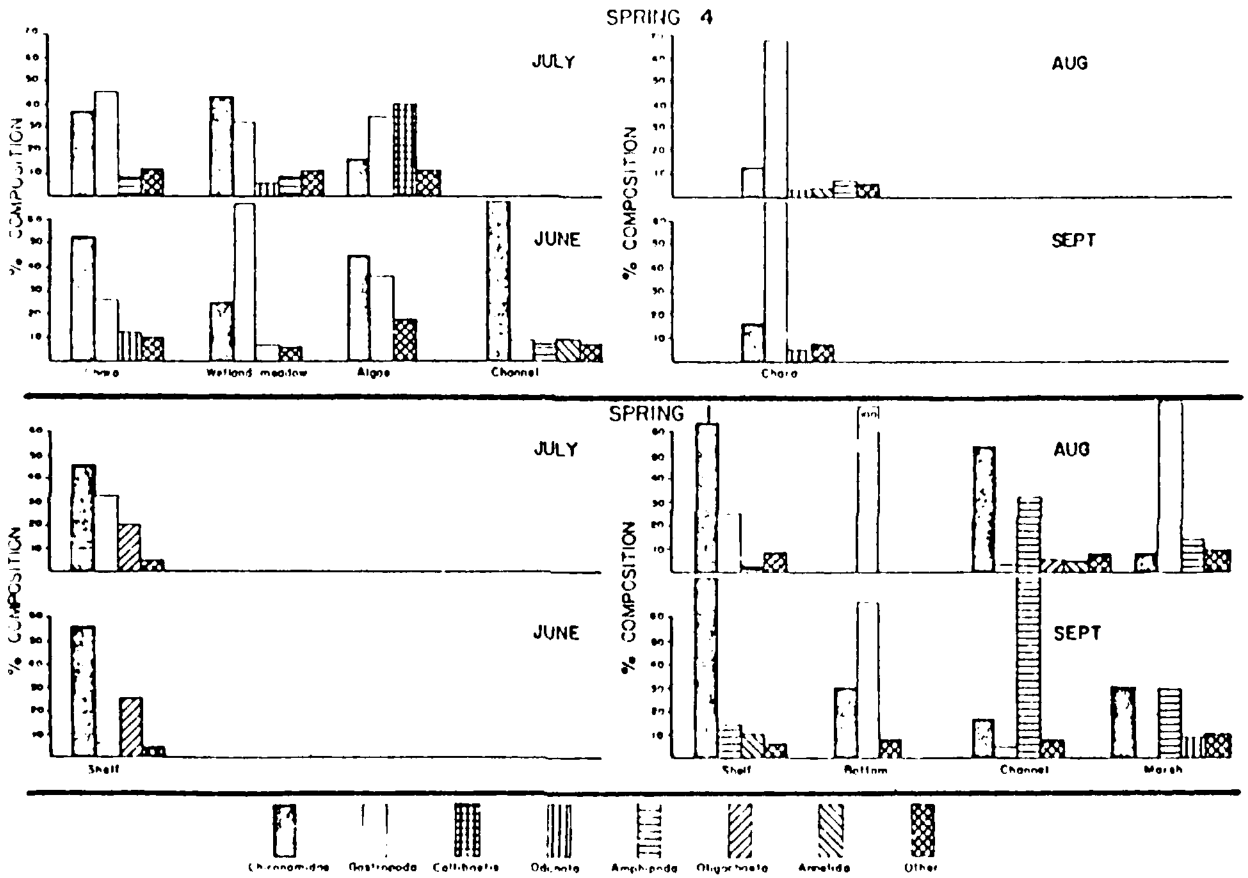


Figure 10. Percent composition of major taxonomic groups in Springs 1 and 4, June - September 1980.

Table 10. Density of macroinvertebrate taxa in Spring 1, June - September 1980.

Species	6/80	7/80	8/80				9/80			
	Shelf	Shelf	Shelf	Bottom	Channel	Marsh	Shelf	Bottom	Channel	Marsh
Diptera										
Ceratopogonidae										
Eulalia										
Palpomyia	8	1	1		26		1		7	3
Culicidae						5				
Tabanidae										
Chrysops					1	1				
Chironomidae										
Chironomidae pupae	4		2		2	3			5	1
Chironomus decorus gr.		5					3	2	12	4
Pseudochironomus richardsoni					7	8	314		93	113
Paratanytarsus sp.	45	4			73		28		8	1
Eukiefferiella calvescens gr.										
Cricotopus sylvestris gr.			85		389	22	25		80	34

Table 10. Continued

Species	6/80	7/80	8/80				9/80			
	Shelf	Shelf	Shelf	Bottom	Channel	Marsh	Shelf	Bottom	Channel	Marsh
Diptera (continued)										
Chironomidae (continued)										
Orthocladius spp.	19	10			10					
Psectrotanypus sp.	73	32	107		36	7	45	7	40	13
Tanypus sp.					1					
Ephemeroptera										
Baetidae										
Callibaetis sp.	3	0	7		2	5	15			11
Coleoptera										
Curculionidae					1					
Dytiscidae										
Copelatus sp.										1
Gyrinidae										
Gyrinus pleuralis					2					

Table 10. Continued

Species	6/80	7/80	8/80				9/80			
	Shelf	Shelf	Shelf	Bottom	Channel	Marsh	Shelf	Bottom	Channel	Marsh
Coleoptera (continued)										
Haliplidae										
Haliplus sp.	0	1				10				10
Peltodytes callosus (A)			1			2	1		1	
Hydrophilidae										
Tropisternus sp.						5				3
Tropisternus orvus										1
Tropisternus sublaevis (A)						3				1
Odonata										
Anisoptera	0	0								
Libellula commanche										1
Zygoptera										
Ischnura sp.			2			3	4			46
Lestes congener	0	1								

Table 10. Continued

Species	6/80	7/80	8/80				9/80			
	Shelf	Shelf	Shelf	Bottom	Channel	Marsh	Shelf	Bottom	Channel	Marsh
Hemiptera										
Corixidae										
<u>Hesperocorixa laevigata</u>	7	1	3		4	18	3			32
Notonectidae										1
<u>Notonecta spinosa</u>									1	1
<u>Notonecta undulata</u>						1				
Homoptera			1							
Trichoptera										
<u>Hydroptila</u>			1							
Annelida										
<u>Erpodella</u> sp.					1	10			1	
<u>Erpodella punctata</u>									1	
<u>Helobdella stagnalis</u>	1	0			53	2	59		64	1
<u>Thermoyson tessulatum</u>					1	1				

Table 10. Continued

Species	6/80	7/80	8/80				9/80			
	Shelf	Shelf	Shelf	Bottom	Channel	Marsh	Shelf	Bottom	Channel	Marsh
Crustacea										
Gammarus lacustris	2	0	1		136	9	26		293	28
Hyallela azteca	2	0	8		175	48	59		742	129
Oligochaeta										
Naidadae	66	23	5		46	2			27	
Gastropoda										
Gyralus sp.	5	14	8	1	1	240	3	1	10	73
Lymnaea spp.	5	15	56		5	41	2	15	23	24
Physa spp.	5	7	13		15	21	2	3	9	9
Pelecypoda										
Psidium sp.			5		2			2	7	
Total	245	114	306	1	989	467	590	30	1424	541

Table 11. Density of macroinvertebrate taxa in Spring 4, June - September 1980.

	6/80				7/80				8/80	9/80
Species	Chara	Wetland meadow	Fil. green algae	Channel	Chara	Wetland meadow	Fil. green algae	Channel	Chara	Chara
Diptera										
Ceratopogonidae								Dry		
Eulalia sp.		1		1						1
Palpomyia sp.					7				1	
Chironomidae										
Chironomidae pupae			1	4						
Tanytarsus sp.									4	
Paratanytarsus sp.	5	36	4	273	7	38	3		5	2
Chironomus sp. _decorus_ gr.	11	1	1	2	13		3		5	4
Parachironomus sp.		8	1							
Pseudochironomus richardsoni	2	57	1	1	27	47	1		23	37
Coryneura sp.	6		1		7	9				
Cricotopus sylvestris gr.					5		1		40	

Table 11. Continued

Species	6/80				7/80				8/80	9/80
	Chara	Wetland meadow	Fil. green algae	Channel	Chara	Wetland meadow	Fil. green algae	Channel	Chara	Chara
Diptera (continued)								Dry		
Chironomidae (continued)										
Orthocladinae					6					
Orthocladius spp.	10	10	3	50	5					
Eukiefferiella calvescens gr.	24	17	8	2	97	163	39			
Parakiefferiella sp.					21	45	1			
Psectrotanypus sp.	15		16	12	42	7	7		12	
Tanypus sp.				25	16					8
Ephemeroptera										
Baetidae										
Callibaetis sp.	1	3	2	5	32	53	145		31	5
Coleoptera										
Dytiscidae										
Agabus sp.				8		7				

Table 11. Continued

Species	6/80 Chara	6/80 Wetland meadow	6/80 Fil. green algae	6/80 Channel	7/80 Chara	7/80 Wetland meadow	7/80 Fil. green algae	7/80 Channel	8/80 Chara	9/80 Chara
Coleoptera (continued)										
Dytiscidae (continued)										
Colymbetinae				1						
Copelatus sp.										2
Cybister explanatus (A)					1					
Hydroporus	1			13	1	6			2	
Haliplidae										
Peltodytes callosus	4		9	4	2	6	18	Dry		
Peltodytes callosus (A)										
Haliplus sp.	1				1	1				
Hydrophilidae										
Hydrobius suscipes (A)		1								
Tropisternus sp.		1			3	2	1		4	
Tropisternus orvus (A)						1				

Table 11. Continued

Species	6/80 Chara	6/80 Wetland meadow	6/80 Fil. green algae	6/80 Channel	7/80 Chara	7/80 Wetland meadow	7/80 Fil. green algae	7/80 Channel	8/80 Chara	9/80 Chara
Hemiptera								Dry		
Corixidae										
Hesperocorixa laevigata	5		1		2	7	2		7	11
Notonectidae										
Notonecta spinosa										2
Odonata										
Anisoptera										
Libellula commanche	1	1								1
L. composita				1						
L. quadrinaculata					1					3
Plathemis subornata				1						
Aeshna sp.										1
Zygoptera										
Ischnura sp.	11	21			5	40			28	11
Lestes congener	4	1	1							

Table 11. Continued

	6/80				7/80				8/80	9/80
Species	Chara	Wetland meadow	Fil. green algae	Channel	Chara	Wetland meadow	Fil. green algae	Channel	Chara	Chara
Annelida										
Erpodella punctata		1		7	1	3	1			
Glossiphonia heteroclita			2							
Helobdella stagnalis	1	5		47	7	1	9		25	4
Crustacea										
Gammarus lacustris				12	32	29	1		34	
Hyallela azteca		7	1	31	26	28	2		17	1
Oligochaeta										
Naidadae		1			2				4	
Gastropoda										
Gyralus sp.	19	109	7	19	113	98	60		193	90
Lymnaea spp.	7	211	22	27	113	66	49		253	104
Physa spp.	8	22		7	86	66	13		70	32

Table 11. Continued

Species	6/80				7/80				8/80	9/80
	Chara	Wetland meadow	Fil. green algae	Channel	Chara	Wetland meadow	Fil. green algae	Channel	Chara	Chara
Pelecypoda								Dry		
Psidium sp.		1							4	5
Total	136	514	79	558	681	724	356		766	325

Table 12. Shannon Weaver species diversity indices for macroinvertebrate populations in Spring 1 and Spring 4, June-September 1980.

		6/80	7/80	8/80	9/80
Spring 1 (avg.)		2.74	2.88	2.09	2.45
Habitat Types	Shelf	2.74	2.88	2.58	2.58
	Bottom	-	-	0	2.01
	Channel	-	-	3.05	2.01
	Marsh below Spring 1	-	-	2.73	3.23
Spring 4 (avg.)		3.12	3.30	3.04	2.82
Habitat Types	Chara	3.72	3.70	3.04	2.82
	Wetland Meadow	2.71	3.59	-	-
	Fil. Green Algae	3.19	2.63	-	-
	Channel	2.86	-	-	-

recorded for Spring 4 than Spring 1 during each month sampled. Diversity values for the channel below Spring 4 and the channel and marsh below Spring 1 were generally similar.

Ecological relationships for the common macroinvertebrates collected are summarized in Table 13. Most species were typical of lentic-littoral habitats, often in association with vascular hydrophytes. All major functional trophic groups were represented with collectors, gatherers, and scrapers being the most numerically abundant in the invertebrate samples. Most of the species collected had widespread or western distributions in the U.S.

Fish

Least chubs and Utah chubs were the only fish collected at Leland Harris. Both species were found at locations throughout the spring-marsh complex from June to September.

Seining was the primary collection technique employed in June; however, in the remaining sample periods (July-September) a combination of seining, netting, and trapping techniques were employed with a resulting increase in sampling effectiveness.

Population Structure

Length frequency histograms compiled from all sample sites each month for least chubs (Figure 11) show two distinct year classes each month and the possible remnants of a third. Recruitment fish ranged

Table 13. Ecological and distributional data[1] for selected macroinvertebrate species present in Leland Harris Springs Complex, June - September 1980.

Taxa	North American distribution[2]	Habitat[3]	Trophic relationships[3]
Insecta			
Coleoptera			
Dytiscidae			
Agabus sp.	T	Lentic-vascular hydrophytes	Piercers-carnivores
Colymbetes sp.	T	Lotic aepositional	Piercers-carnivores
Cybister explanatus	T	Lentic-vascular hydrophytes	Piercer-carnivore
Halipidae			
Peltodytes sp.	T	Lentic-vascular hydrophytes	Piercers and shredders herbivores - Engulfers (predators)
Haliplus sp.	T	Lentic-vascular hydrophytes	Piercers and shredders herbivores
Hydrophilidae			
Hydrobius fuscipes	E, S, Calif.	Lentic-littoral	?
Tropisternus orvus	T	Lentic-littoral lotic-	?

Table 13. Continued

Taxa	North American distribution[2]	Habitat[3]	Trophic relationships[3]
Diptera			
Ceratopogonidae			
<u>Palpomyia</u>	T	Lotic-depositional (detritus)	Engulfers (predators)
Stratiomyiidae			
<u>Eulalia</u>	T	Lentic-vascular hydrophytes	Collectors-gatherers
Chironomidae			
<u>Chironomus</u>	T	Lentic-littoral lotic-depositional	Collectors-gatherers shredders-herbivores
<u>Coryneura</u>	T	Lentic-littoral lotic-depositional	Collectors-gatherers
<u>Cricotopus</u>	T	Lentic-vascular hydrophytes, algalmats and detritus	Shredders-herbivores
<u>Orthocladius</u>	T	Lentic-littoral lotic-errosional	Collectors-gatherers (detritus, diatoms, fil. algae)
<u>Parachironomus</u>	T	Lentic-littoral	Engulfers (predators) collectors-gatherers

Table 13. Continued

Taxa	North American distribution	Habitat	Trophic relationships
Chironomidae (continued)			
Psectrotanypus (Anatopynia)	T	Lotic-depositional	Engulfers (predators on [illegible])
Tanypus	T	Lentic-littoral	Engulfers and piercers (predators); collectors-gatherers (diatoms, filamentous green algae, detritus)
Eukiefferiella	T	Lotic-erosional, Lentic-littoral	Collectors-gatherers, scrapers, engulfers (predators on chironomid eggs and larvae)
Pseudochironomus	T	Lentic	Collectors-gatherers
Tanytarsus		Lentic-vascular hydrophytes	Collectors-filters and gatherers, some scrapers
Parakiefferiella	T	Lotic-erosional, Lentic-littoral	Collectors-gatherers
Ephemeroptera			
Baetidae			
Callibaetis	T	Lentic-vascular hydrophytes	?
Hemiptera			
Belastomatidae			
Lethocerus americanus	N	Lentic-littoral	Piercers-carnivores

Table 13. Continued

Taxa	North American distribution[2]	Habitat[3]	Trophic relationships[3]
Hemiptera (continued)			
Corixida			
Hesperocorixa laevigata	T	Lotic-depositional lentic	Piercers-carnivores
Gerridae			
Gerris		Lentic-limnetic	Piercers-carnivores (scavengers)
Notonectidae			
Buenoa margaritacea	T	Lentic-littoral	Piercers-carnivores
Notnecta spinosa	T	Lentic-littoral Lotic-depostional	Piercers - carnivores (including cannibalism)
Odonata			
Aeshnidae			
Anax junius	T	Lentic-vascular hydrophytes	Engulfers (predators)
Anax walsinghami	SW	Lentic-vascular hydrophytes	Engulfers (predators)
Libellulidae			
Erythemis collocata (A)[4]	W	Lentic-littoral (silt detritus and vascular hydrophytes)	Engulfers (predators)
Libellula comanche	W	Lentic littoral (silt detritus and vascular hydrophytes)	Engulfers (predators)

Table 13. Continued

Taxa	North American distribution[2]	Habitat[3]	Trophic relationships[3]
Libellulidae (continued)			
Libellula composita	W	Lentic littoral (silt detritus and vascular hydrophytes)	Engulfers (predators)
Libellula quadrimaculata	T	Lentic littoral (silt detritus and vascular hydrophytes)	Engulfers (predators)
Plathemis subornata (A)	W & C		
Tarnetrum corruptum (A)			
Coenagrionidae			
Ischnura	T	Lentic-vascular	Engulfers (predators cladocera)
Lestidae			
Lestes congener	W	Lentic-vascular hydrophytes	Engulfers (predators)
Annelida			
Oligochaeta			
Aeolosomatidae			

Table 13. Continued

Taxa	North American distribution[2]	Habitat[3]	Trophic relationships[3]
Hirudirea			
Erpodella punctata	T	Lentic and lotic	Predator - scavenger
Glossiphonia heteroclita	?		
Helobdella stagnalis	T	Lentic-lotic	
Crustacea			
Amphipoda			
Taltridae			
Hyallela azteca	T	Lentic-lotic	Collector, gatherer
Gummaridae			
Gammarus lacustris	N	Lentic-lotic	Collector, gatherer
Mollusca			
Gastropoda			
Physa	T	Lentic	Scraper
Lymnaea	T	"	"
Gyralus (torquis)	T	"	"

Table 13. Continued

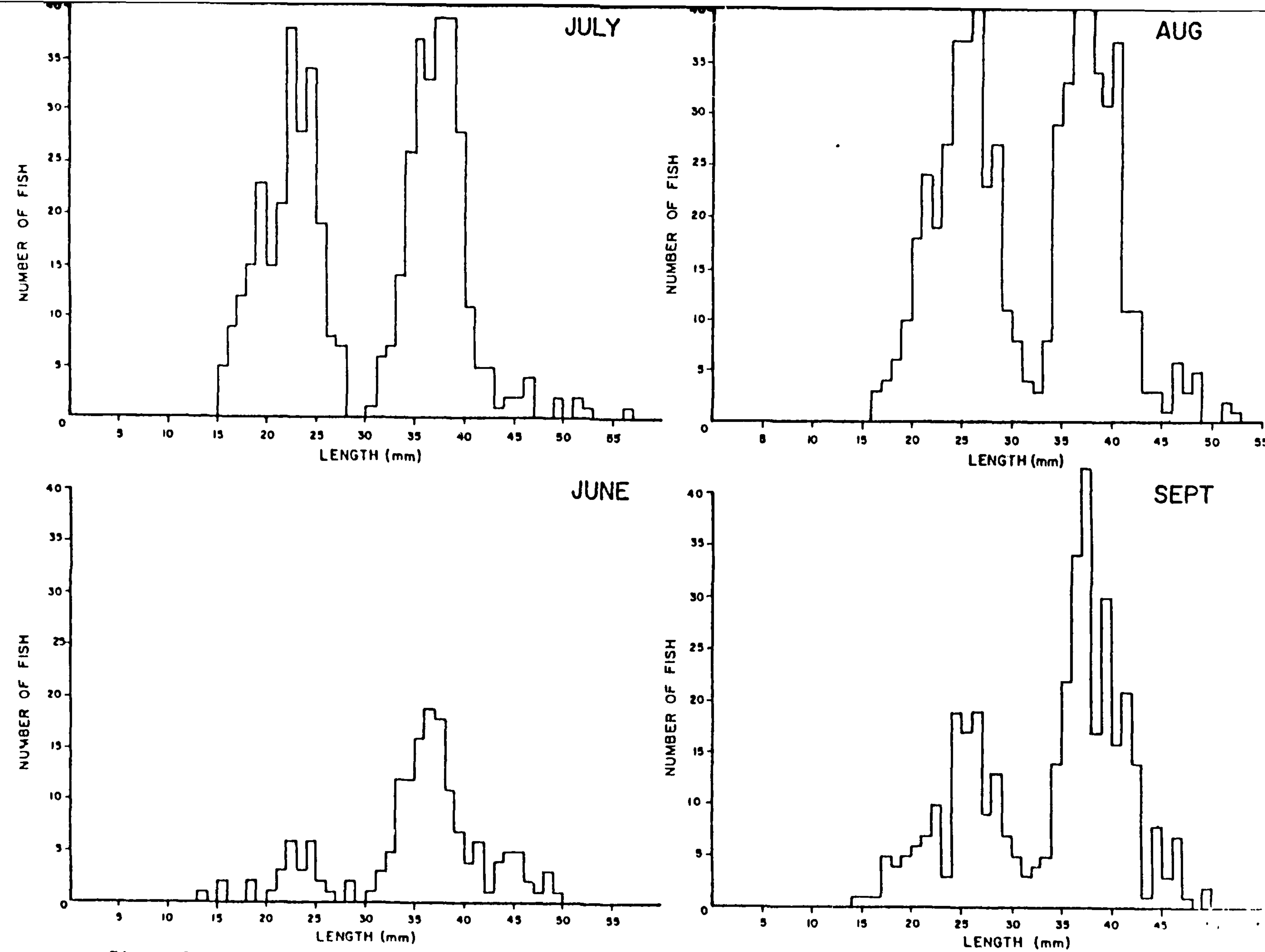
Taxa	North American distribution[2]	Habitat[3]	Trophic relationships[3]
Pelecypoda			
<u>Psidium</u> <u>subtruncatum</u>		Lentic	

[1]From Merritt and Cummins 1978, Musser 1962, Usinger 1956, and Penñack 1978.

[2]T - transcontinental, E - east, S - south, N - north, W - west.

[3]For definition of terms see Merritt and Cummins 1978.

[4]A - designates adult forms; all others, nymphs.



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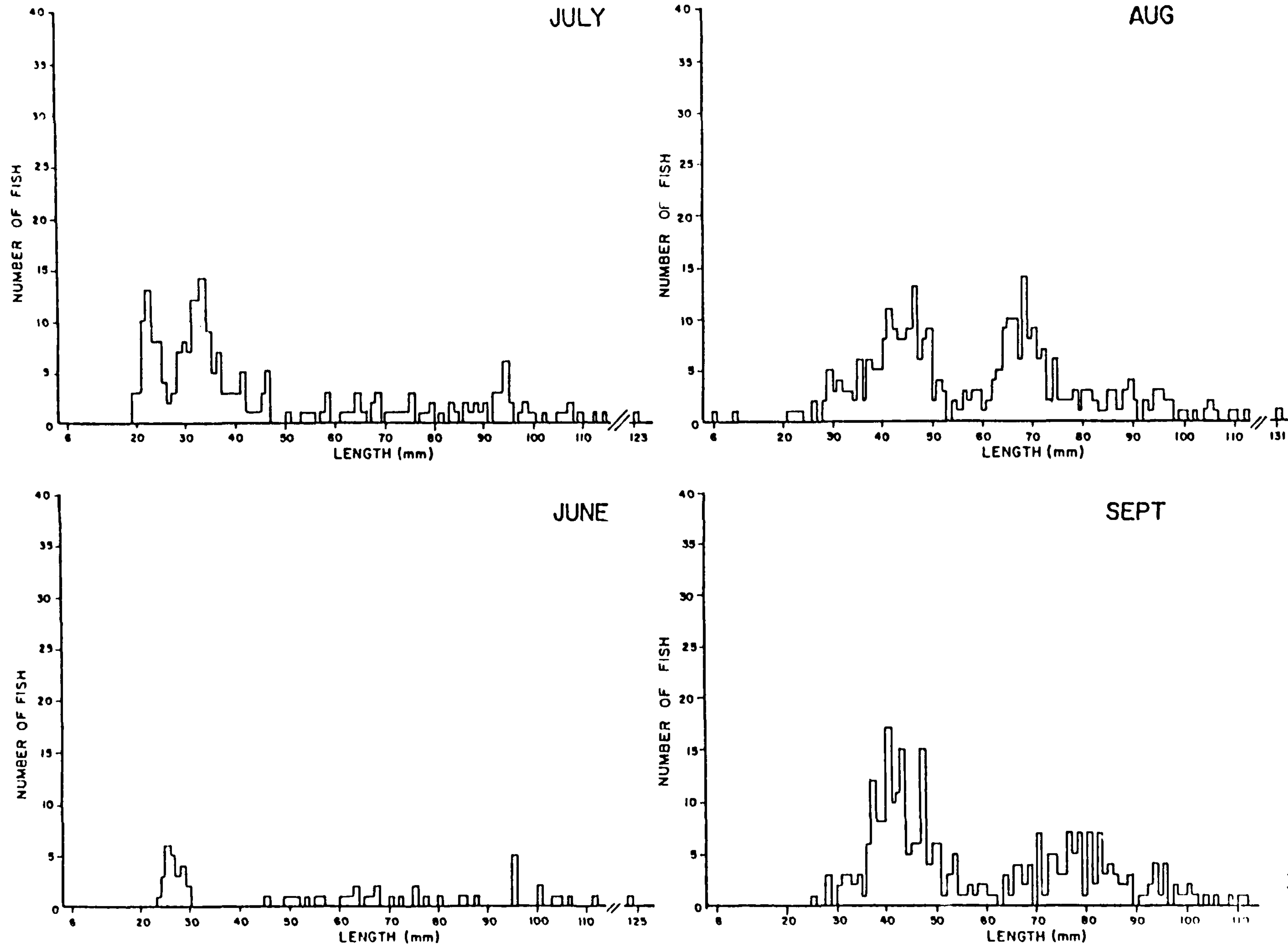


Figure 12. Length-frequency histograms for Utah chubs, June - September 1980.

in size from 11 to 30 mm, total length. Average size was similar in June and July but increased slightly in August and September (Table 14). Adult fish varied from 31 to 57 mm in size. Average size of the adult fish also showed only slight increases in August and September.

Table 14. Average size (mm) of adult and recruitment least and Utah chubs during June, July, August, and September 1980.

	Recruitment		Adult
	Least Chub	Utah Chub	Least Chub
June	23.03	26.03	38.39
July	22.53	30.50	38.05
August	25.36	36.16	38.48
September	26.18	41.75	39.24

Length-frequency histograms for Utah chubs (Figure 12) show the first two year classes in August and September when sample sizes were large; only young-of-the-year are obvious in June and July as a result of the smaller sample size on which they are based. Average size of recruitment fish increased from 26.03 in June to 41.75 in September. An undetermined number of older age classes were also present.

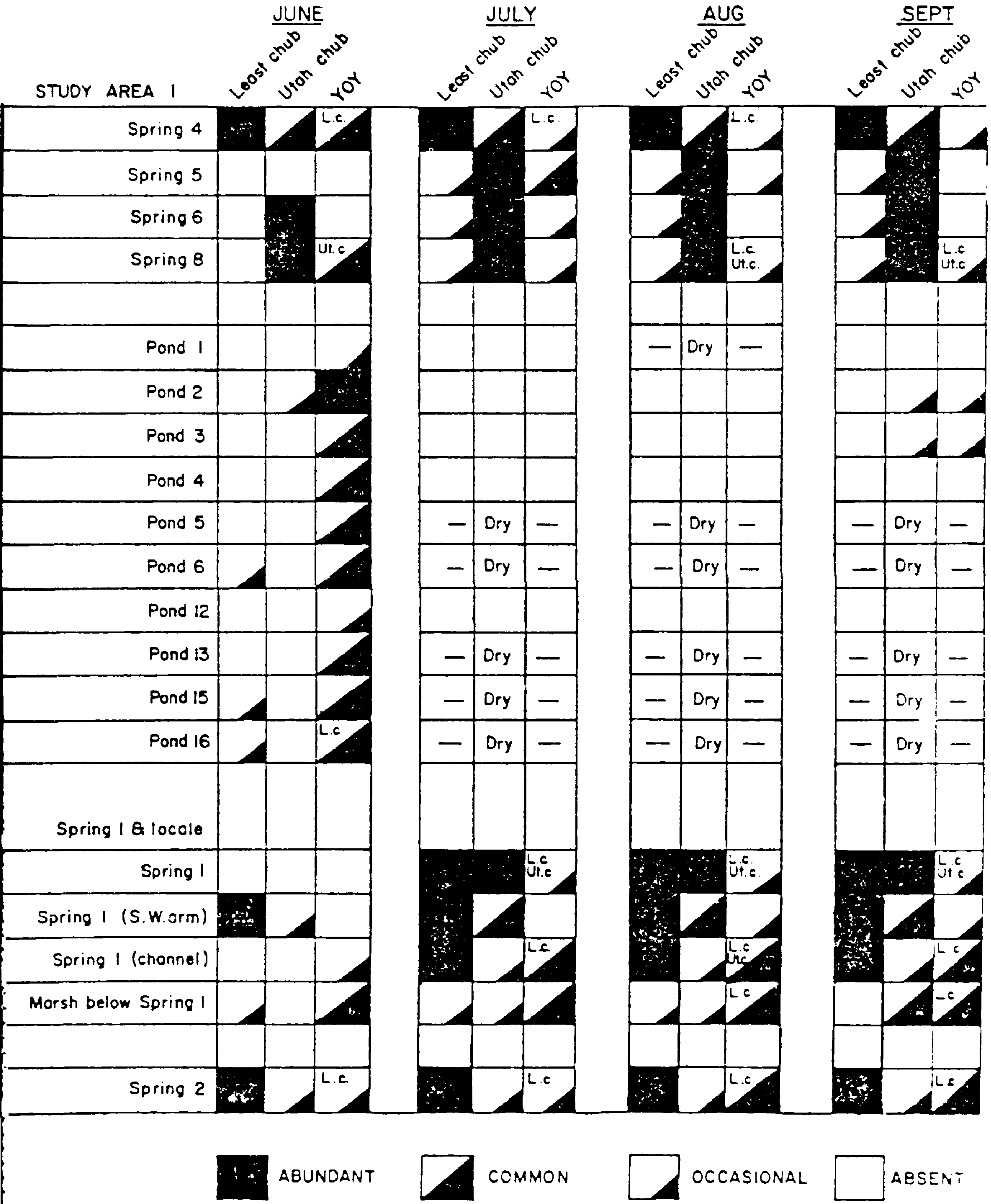
Distribution and Abundance

Absolute population estimates were impossible to make in many springs due to the nature of the area being sampled. Springs 8 and 6, for example, contained ledges and small, deep holes into which fish retreated at any disturbance; Spring 5 was so small that it was impossible to seine. Catches for Spring 4 and the southwest arm of Spring 1 (Table 15) came close to approximating total populations because it was possible to visually observe all the fish in these areas and estimate the effectiveness of sampling. Attempts to estimate populations by mark and recapture methods were successful only on the southwest arm of Spring 1 due to low numbers of recaptures. Qualitative estimates of fish abundance (Figure 13) for other sites were based on visual observations, seining and trapping. Young-of-the-year were not differentiated into Utah chub or least chub in Figure 13 unless seining or trapping permitted an identification to species. Question marks for adult fish indicated only a probable identification of the adult based on visual observations without subsequent collection.

Table 15. Total catches of least and Utah chubs at selected sites, and qualitative estimates of sampling efficiency, June - September 1980.

	Spring 4		SW Arm Spring 1	
	Total numbers (LC/UT C)	Estimated sampling efficiency	Total numbers (LC/UT C)	Estimated sampling efficiency
6/80	151/37	50-75%	31/2	50%
7/80	512/23	75-90%	1068/12	75%
8/80	240/24	75-90%	905/34	75%
9/80	100/6	75-90%	392/6	50%

Figure 13. Qualitative abundance estimates of least and Utah chubs at 19 sites in the Leland Harris Springs Complex.



Trap Data

Minnow traps were emplaced in a number of locations throughout the Leland Harris complex for the purpose of monitoring fish usage of particular areas; of special interest was utilization of spring-heads in relation to channel and marsh areas with which they were associated. Locations monitored included Spring 4 and vicinity and the Spring 5 - Pond 2 system in Study Area 1, Spring 10 and associated areas located below Study Area 1 and Spring 1 and associated areas in Study Area 2.

Spring 4

Figure 14 denotes the location of traps in and around Spring 4 for July and August-September. Table 16 summarizes catch and water quality data for July and Table 17 includes the same information for August and September. Highest catches always occurred in the spring-head. Pond 1, below the spring exhibited a 0 catch rate and dried up in August before partially refilling in September. Catch rates for the marshy area above Spring 4 were low in July and August but increased slightly in September. Conditions in the open marsh area (Tc) as opposed to in the bullrushes (a and b) were marginal since all the fish caught in Tc in September apparently died as a result of oxygen depletion during the night.

Spring 5 - Pond 2

Four traps were placed in the Spring 5 - Pond 2 system during July, August, and September (Figure 15). Trapping (Table 18) and visual

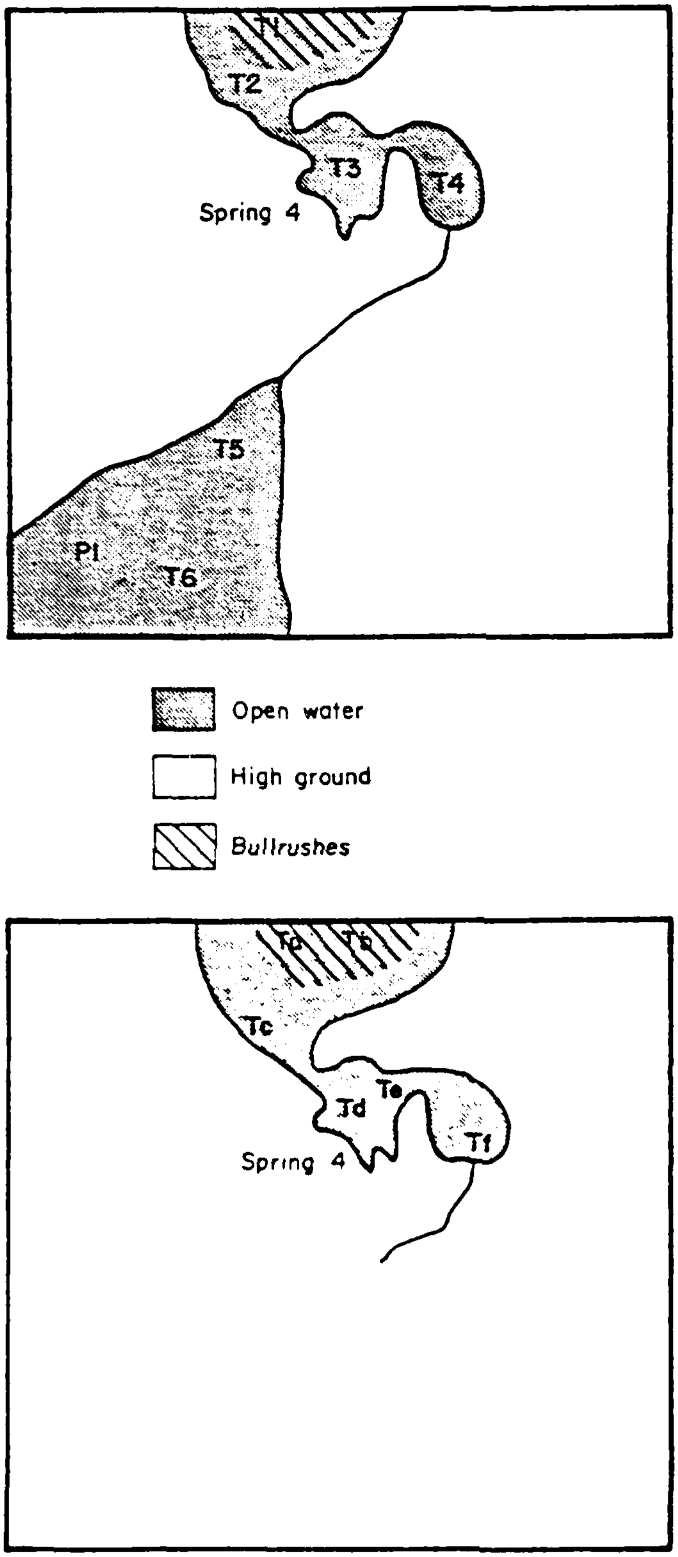


Figure 14. Location of traps around Spring 4 in July and August-September 1980.

Table 16. Catch per unit effort, dissolved oxygen, and temperature at 6 traps around Spring 4 between 2100, July 14, and 1030, July 15, 1980.

		Catch per unit effort (fish/hr)	D.O. (ppm)		Temp. (°C)	
			2115	0500	2115	0500
Marsh	Trap 1 (LC/UT C)	.2/0	4.5	1.1	20.0	15.0
	Trap 2	.3/.6	7.5	1.0	20.0	15.0
Spring 4	Trap 3	31.7/1.5	4.0	2.0	14.5	13.4
	Trap 4	9.8/7.0	9.8	2.5	20.0	15.5
Pond 1	Trap 5	0/0	8.3	0.8	23.0	17.5
	Trap 6	0/0	9.5	6.0	26.0	19.5

Table 17. Catch per unit effort of least and Utah chubs in Spring 4 and vicinity, August and September 1980.

		Time (in/out)	Fish/hr. (LC/UT C)	Temp. (°C)
August 1980				
Marsh	Trap A	1935 0945	.3/0	12.5
	Trap B	1935 0945	.2/.1	14.0
	Trap C			
Spring 4	Trap D	1935 0925	6.6/.6	
	Trap E	1935 0935	3.2/.4	
	Trap F	1935 0950	2.8/.3	13.5
September 1980				
Marsh	Trap A	1525 0903	.3/.2	15.0
	Trap B	1525 0905	.7/.3	
	Trap C	1000 1500	.6/.4	23.0
	Trap C	1525 0900	.3/.1	13.0
Spring 4	Trap D	1000 1500	17.4/1.2	18.0
	Trap D	1525 0900	.2/.1	15.0

Table 17. Continued

		Time (in/out)	Fish/hr. (LC/UT C)	Temp. (°C)
September 1980 (continued)				
	Trap E			
	Trap F	1000 1500	2.4/0	22.0

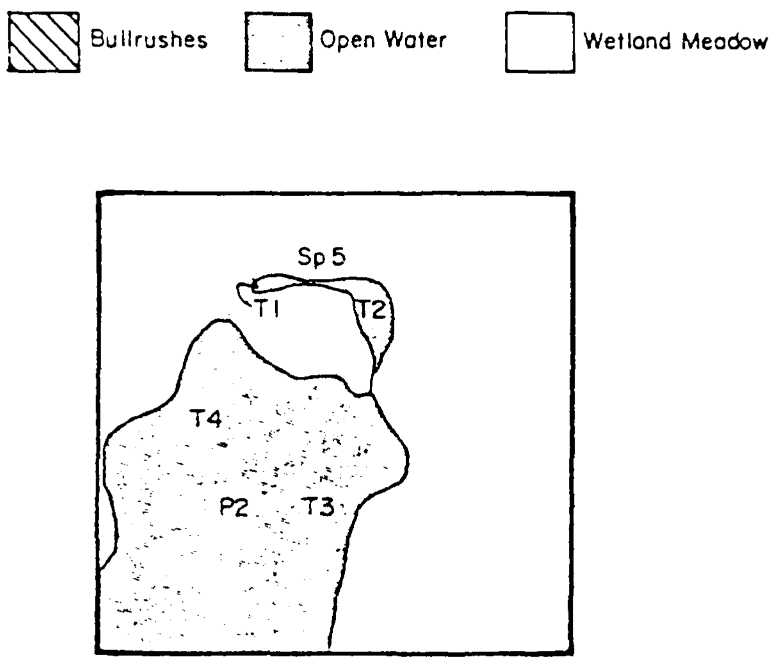


Figure 15. Location of traps in Spring 5 and Pond 2, July - September 1980.

Table 18. Catch per unit effort at four traps in Spring 5 and Pond 2 during July, August, and September 1980.

		Fish/hr. (LC/UT C)	Time	Temp. (°C)	Date
Spring 5	Trap 1	0/42.3	1345-1645	14.0	7/15/80
	Trap 1	0/.8	1945-1000	15.0-14.5	8/19-8/20/80
	Trap 1	0/1.03	1520-1815	15.0	9/16/80
	Trap 1	0/.1	1825-0915	15.0-15.0	9/16-9/17/80
	Trap 2	4.0/25.3	1345-1645	16.0	7/15/80
	Trap 2	0/36	1945-1000	14.5-15.0	8/19-8/20/80
	Trap 2	0/.3	1520-1820	15.5	9/16/80
	Trap 2	.1/1.89	1825-0920	15.5	9/16-9/17/80
Pond 2	Trap 3	0/0	1345-1645	27.0	7/15/80
	Trap 3	0/0	1950-1010	19.0	8/19-8/20/80
	Trap 3	0/.3	1520-1820	27.0	9/16/80
	Trap 3	0/0	1825-0934	27.0	9/16-9/17/80
	Trap 4	0/0	1345-1645	30.0	7/15/80
	Trap 4	0/0	1945-1010	19.0	8/19-8/20/80
	Trap 4	0/0	1520-1820	28.0	9/16/80
	Trap 4	0/.1	1820-0938	28.0	9/16-9/17/80

observations showed Utah chubs primarily used the springhead during July and August with zero catch rates recorded for the pond areas during those months. September traps showed somewhat decreased utilization of the springhead and an increase in the pond, though catch rates were still low. In contrast, visual observations of these areas in June indicated no fish in the springhead and numerous young-of-the-year and adult fish in Pond 2.

Spring 10

Spring 10 was located immediately below Study Area 1 (Figure 2). During the September sample period, traps were emplaced in the springhead (T1 and T2), channel (T3), and marsh (T4) (Figure 16). Highest catch rates were recorded for the springhead; however; channel and marsh areas also exhibited relatively high catch rates for fish (Table 19). Least chubs primarily occurred in the channel and marsh while Utah chubs dominated the springhead.

Spring 1

Spring 1, its channel, and associated marsh were the most intensively trapped areas in this study. A total of eight traps were placed in two habitat types in the springhead itself and in proximal portions of the outlet channel in August (Figure 17). Table 20 summarizes the catch per unit effort of each trap. Adult Utah chubs (50 mm+) were found only in the spring's deep water and shelves. Adult least chubs were distributed through all the habitat types but also sustained highest densities (10-13 fish/hr.) in the spring's deep water and shelf areas.

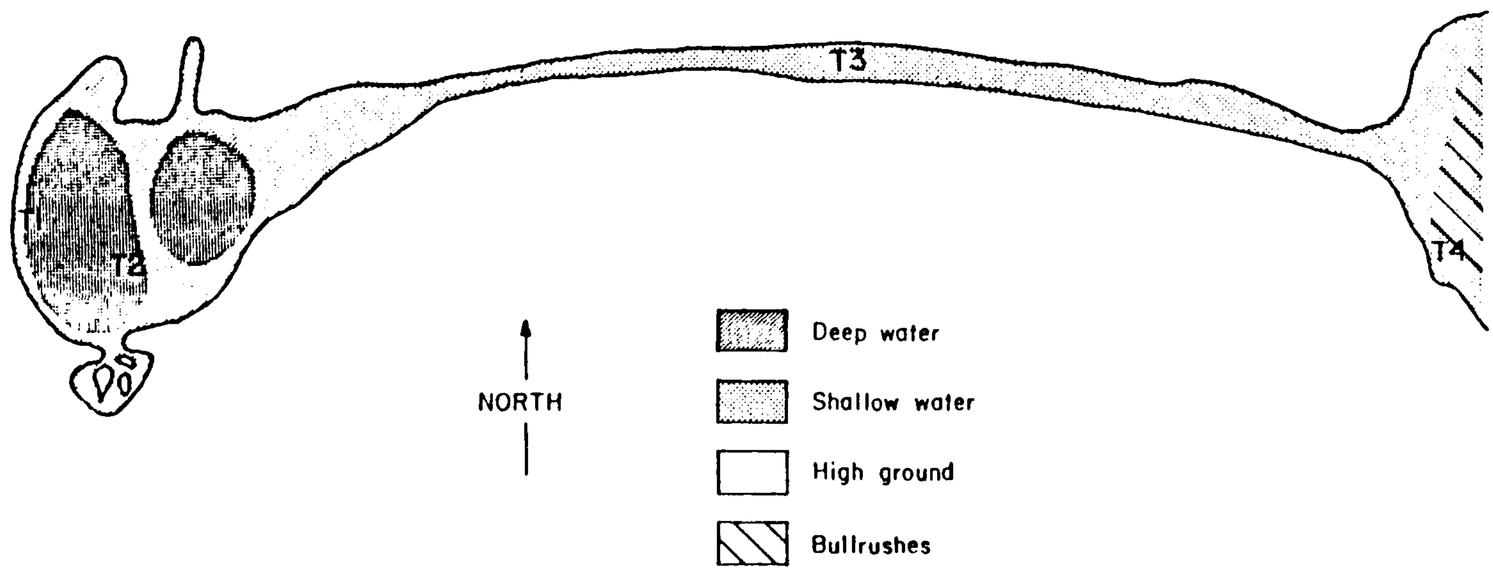


Figure 16. Location of traps around Spring 10, September 1980.

Table 19. Catch per unit effort of least and Utah chubs at four locations around Spring 10, September 16-17, 1980.

	Day	Time	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)	Total sample size (LC/UT C)	Temp. (°C)
Trap 1	9/16	1540 1850	0/2.2	0/0	0/7	15.0
"	9/16-17	1920 1150	0/1.7	.1/.2	1/32	
Trap 2	9/16	1540 1855	.3/11.1	0/0	1/36	15.0
"	9/16-17	1920 1207	.2/2.5	0/.5	4/50	
Trap 3	9/16	1540 1905	7.0/1.7	0/0	35/6	15.0
"	9/16-17	1910 1220	1.1/.8	.7/0	30/14	
Trap 4	9/16	1545 1915	4.0/0	0/0	14/0	16.3
"	9/16-17	1915 1252	.5/.1	0/0	8/1	20.0

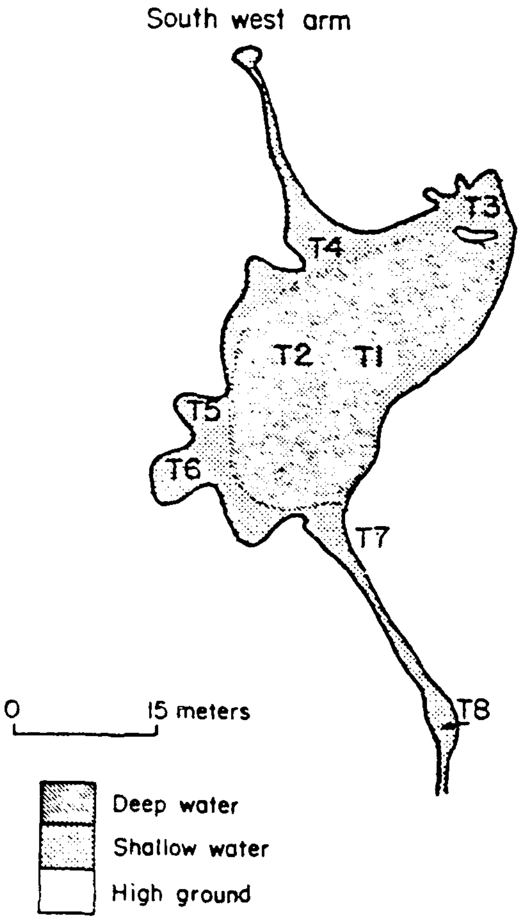


Figure 17. Location of traps in springhead #1, August 1980.

Table 20. Catch per unit effort for least and Utah chubs in two different habitat types in Spring 1 and in channel below, August 20-21, 1980.

	Deep water		Shelf				Channel	
	Trap 1	Trap 2	Trap 3	Trap 4	Trap 5	Trap 6	Trap 7	Trap 8
Time In	1730	1730	1730	1730	1730	1730	1730	1730
Time Out	0900	0900	1150	1200	1130	1130	1110	1110
Y-O-Y/hour (LC/UT C)	.1/0	.1/1.4	5.3/.4	5.0/0	4.4/.4	3.4/.2	31.8/0	.2/.2
Adults/hour (LC/UT C)	6.3/.7	10.8/1.8	12.9/.1	1.9/.1	5.7/.1	5.3/.1	8.1/0	0/0
Total Sample Size (LC/UT C)	99/50	169/50	333/9	128/1	182/9	157/6	707/0	4/3

Young-of-the-year least chubs exhibited low densities (<1 fish/hr.) in the deep, open waters of the springhead, moderate numbers in the shelf areas (3-5 fish/hr.) and highest densities in the channel (32 fish/hr.).

Additional traps were emplaced from the SW arm of Spring 1 to the marsh below it (Figure 18) in July, August, and September. Three traps (T1, T2A, T2B) were emplaced in portions of the main spring. Four traps (T3, T4, T5, T6) were situated in the outflow channel of Spring 1 between the spring and marsh. Trap 7 was located in open water of the upper marsh, trap 8 in a deeper (1.5-2.0) hole in the marsh. Traps 9A and 9B were in open, shallow water while 10A and 10B were placed among bullrushes in the marsh. Not every trap location was utilized each time a trap series was run. Catch per unit effort data for these locations for each month is presented in Tables 21, 22, and 23. Water quality information for some trap sites is presented in Tables 24 and 25. Catch rate patterns were generally similar to the other springs with highest catches of adult fish generally occurring in the springheads and lowest in the marshes. Least chub young-of-the-year tended to be more common in the channel and marsh below Spring 1 than in the springhead (Table 26).

Activity Patterns

The trapping scheme employed was not specifically designed to reveal diurnal activity patterns of fish. However, trapping in the Spring 1 system was generally patterned on a day-night basis.

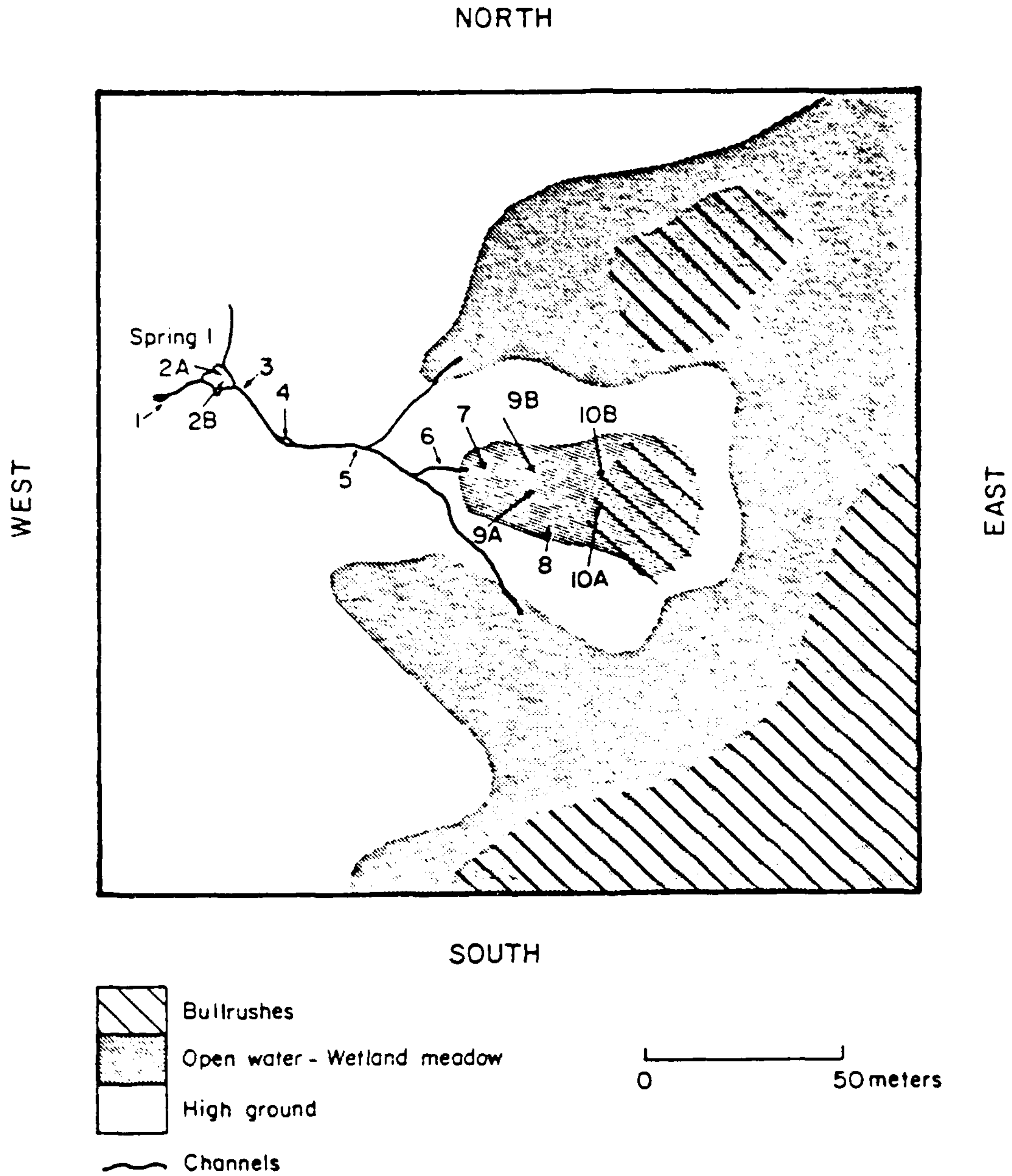


Figure 18. Location of traps around Spring 1, July - September 1980.

Table 21. Catch per unit effort for least and Utah chubs and total numbers sampled in Spring 1 and associated areas, July 16-18, 1980.

	Day	Time (in/out)	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)	Total sample size (LC/UT C)
Trap 1	7/16	1620 0930	.4/.3	14.5/.4	252/7
Trap 2A	7/16	1615 1205	0/0	12.5/.4	247/8
Trap 4	7/17	1235 1550	17.5/.6	5.2/0	74/2
"	7/17	1550 2015	6.9/0	.9/0	35/0
"	7/17-7/18	2015 0810	1.9/0	1.8/0	44/0
Trap 5	7/17	1238 1605	32.29/.6	13.7/0	151/2
"	7/17	1605 2020	4.2/0	.5/0	20/0
"	7/17-7/18	2020 0825	1.4/0	.6/0	24/0
Trap 6	7/17	1240 1620	13.1/0	0/0	49/0
"	7/17	1620 2025	4.8/0	0/0	19/0
"	7/17-7/18	2025 0835	.1/0	.7/.1	9/1
Trap 8	7/17	1245 1630	.8/.3	22.1/0	86/1
"	7/17	1630 2030	1.3/2.5	34.0/0	141/10
"	7/17-7/18	2030 0840	2.1/0	4.8/.6	85/7

Table 21. Continued

	Day	Time (in/out)	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)	Total sample size (LC/UT C)
Trap 9A	7/17	1245 1640	.3/0	0/0	1/0
"	7/17	1640 2040	3.0/0	.8/0	15/0
"	7/17-7/18	2040 0855	.1/0	0/0	1/0
Trap 10A	7/17	1245 1642	1.5/0	.8/0	9/0
"	7/17	1642 2050	7.3/0	1.5/0	35/0
"	7/17-7/18	2050 0858	10.9/0	.4/.1	136/2

Table 22. Catch per unit effort for least and Utah chubs in Spring 1 and associated areas, August 20-21, 1980.

	Day	Time (in/out)	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)	Total sample size (LC/UT C)
Trap 2A	8/20-21	1730 0900	.1/0	6.3/.7	99/10
Trap 2B	8/20-21	1730 0900	.1/1.4	10.8/1.8	169/50
Trap 3	8/21	1400 1955	23.2/.2	.8/0	144/1
"	8/21-22	1955 0025	.2/0	.2/0	6/0
"	8/22	0025 0703	1.7/0	2.3/0	26/0
Trap 4	8/21	1400 2005	19.8/.3	6.0/0	155/2
"	8/21-22	2008 0028	4.2/.4	2.0/0	28/0
"	8/22	0028 0705	1.4/0	2.0/.2	22/1
Trap 5	8/21	1404 2015	20.5/0	3.4/0	149/0
"	8/21-22	2015 0030	2.6/0	4.9/0	32/0
"	8/22	0030 0707	5.1/0	2.9/.5	52/3
Trap 6	8/21	1405 2036	2.3/0	0/0	15/0
"	8/21-22	2036 0040	4.0/0	1.8/0	23/0
"	8/22	0040 0711	.5/0	0/0	3/0

Table 22. Continued

	Day	Time (in/out)	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)	Total sample size (LC/UT C)
Trap 7	8/21	1410 2030	9.4/0	.2/0	60/0
"	8/21-22	2030 0045	2.1/0	0/0	9/0
"	8/22	0045 0716	1.1/0	.2/0	8/0
Trap 8	8/21	1410 2036	11.3/.5	1.2/0	53/2
"	8/21-22	2036 0048	0/0	.2/0	1/0
"	8/22	0048 0718	1.1/0	.8/0	12/0
Trap 9A	8/21	1410 2037	29.2/0	7.1/0	154/0
"	8/21-22	2037 0049	4.0/0	.2/0	18/0
"	8/22	0049 0719	3.1/0	0/0	20/0
Trap 10A	8/21	1410 2038	61.4/.5	5.6/0	285/2
"	8/21-22	2038 0050	2.4/0	0/0	10/0
"	8/22	0050 0720	.8/0	.2/.2	6/1

Table 23. Catch per unit effort for least and Utah chubs in Spring 1 and associated areas, September 17-19, 1980.

	Day	Time (in/out)	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)	Total sample size (LC/UT C
Trap 1	9/17-18	1635 1029	0/.4	12.9/.2	232/11
"	9/18	1106 1630	.4/0	71.3/1.1	394/6
"	9/18	1650 1918	4.4/.4	65.2/0	174/1
"	9/18-19	1951 0720	0/.1	1.3/0	15/1
Trap 2A	9/17-18	1635 0945	0/0	0/2.4	0/42
"	9/18	1110 1605	0/0	10.2/.4	51/2
"	9/18	1650 1912	0/0	.4/.4	1/2
"	9/18-19	1950 0715	0/0	0/.2	0/2
Trap 2B	9/17-18	1635 1022	.2/0	0/.3	4/6
"	9/18	1110 1615	29.0/0	1.0/1.6	150/8
"	9/18	1650 1913	.4/1.3	39.1/.9	89/5
"	9/18-19	1950 0715	0/0	0/1.5	0/17
Trap 4	9/17-18	-			
"	9/18	1150 1655	3.8/0	16.4/.8	101/4

Table 23. Continued

	Day	Time (in/out)	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)	Total sample size (LC/UT C)
Trap 4	9/18	1700 1925	2.4/.8	33.2/0	89/2
"	9/18-19	1947 0720	0/0	.1/.1	1/1
Trap 5	9/17-18	1635 1113	1/.2	8.2/.1	154/4
"	9/18	1215 1700	[illegible]	8.8/0	249/0
"	9/18	1710 1930	60.4/0	20.9/0	183/0
"	9/18-19	1947 0721	2.6/.1	2.8/.1	62/1
Trap 9A	9/17-18	1635 1220	.7/0	.1/0	16/0
"	9/18	1230 1715	.8/0	0/0	4/0
"	9/18	1720 1937	1.8/0	.4/0	5/0
"	9/18-19	1942 0725	.3/0	0/0	3/0
Trap 9B	9/17-18	-			
"	9/18	1230 1715			0/0
"	9/18	1720 1937	.9/0	0/0	2/0
"	9/18-19	1942 0725	0/0	.1/0	1/0

Table 23. Continued

	Day	Time (in/out)	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)	Total sample size (LC/UT)
Trap 10A	9/17-18	1650 1220	.5/0	.6/0	20/0
"	9/18	1230 1720	3.4/0	.4/0	18/0
"	9/18	1720 1940	.4/0	.4/0	2/0
"	9/18-19	1942 0725	.2/.1	.8/0	11/1
Trap 10B	9/17-18	-			
"	9/18	1230 1720	1.5/0	.4/0	9/0
"	9/18	1720 1940	.9/0	.9/0	4/0
"	9/18-19	1942 0730	.3/.1	.2/.3	6/4

Table 24. Water quality at eight trap locations below Spring 1, August 21 and 22, 1980.

	Day	Time	Temp. (°C)	D.O. mg/l	pH	Cond. (umhos)
Trap 3	8/21	1400 1955	18.0 16.0	5.2	7.6	260
"	8/22	0025	12.5	4.0	7.6	
"	8/22	0703	11.5	3.7	7.5	
Trap 4	8/21	1400 2005	18.5 15.0	3.4	7.5	380
"	8/22	0028	12.0	2.8	7.5	
"	8/22	0705	11.0	3.5	7.5	
Trap 5	8/21	1404 2015	20.0 14.0	4.1	7.6	375
"	8/22	0030	12.0	4.7	7.6	
"	8/22	0707	11.5	4.0	7.4	
Trap 6	8/21	1405 2036	21.5 14.0	4.8	7.7	385
"	8/22	0040	12.0	5.2	7.6	
"	8/22	0711	11.2	4.2	7.5	
Trap 7	8/21	1410 2030	29.5 16.0	5.7	7.6	415
"	8/22	0045	11.5	4.8	7.6	
"	8/22	0716	10.0	5.2	7.6	

Table 24. Continued

	Day	Time	Temp. (°C)	D.O. mg/l	pH	Cond. (umhos)
Trap 8	8/21	1410 2036	24.5 22.0	4.0	7.6	600
"	8/22	0048	16.0	1.7	7.4	
"	8/22	0718	11.0	2.2	7.3	
Trap 9A	8/21	1410 2037	30.0 21.0	8.4	8.2	490
"	8/22	0049	13.5	2.8	7.5	
"	8/22	0719	10.5	1.7	7.3	
Trap 10A	8/21	1410 2038	26.0 21.5	8.8	8.2	485
"	8/22	0050	13.0	3.0	7.5	
"	8/22	0720	10.0	4.9	7.4	

Table 25. Water quality at nine trap locations in Spring 1 and vicinity, September 17-19, 1980.

	Day	Time	Temp. (°C)	D.O. (mg/l)	pH	Cond. (umhos)
Trap 1	9/17	1635	14.0	3.2	7.5	380
	9/18	1630	14.0			
	9/18	1918	14.5			
	9/19	0720	13.0			
Trap 2A	9/17	1635	16.0	4.1	7.7	400
	9/18	1605	16.0			
	9/18	1912	15.0			
	9/19	0715	13.0			
Trap 2B	9/17	1635	16.0	4.1	7.7	400
	9/18	1615	16.0			
	9/18	1913	15.0			
	9/19	0715	13.0			
Trap 4	9/18	1655	17.0			
	9/18	1925	15.0			
	9/19	0720	13.0			
Trap 5	9/17	1635	17.0	5.4	7.7	430
	9/18	1700	17.0			
	9/18	1930	15.0			
	9/19	0721	12.0			

Table 25. Continued

	Day	Time	Temp. (°C)	D.O. (mg/l)	pH	Cond. (umhos)
Trap 9A	9/17	1640	27.0	17.4	8.8	490
	9/18	1715	20.0			
	9/18	1937	17.0			
	9/19	0725	12.0			
Trap 9B	9/18	1715	20.0			
	9/18	1937	16.5			
	9/19	0725	12.0			
Trap 10A	9/17	1650	25.0	20.0+	9.0	480
	9/18	1720	20.0			
	9/18	1940	17.5			
	9/19	0725	12.0			
Trap 10B	9/18	1720	20.0			
	9/18	1940	18.0			
	9/19	0730	12.0			

Table 26. Average catch/unit effort for all traps and months for 4 major areas around Spring 1.

	Catch/unit effort	
	Y-O-Y fish/hr. (LC/UT C)	Adult fish/hr. (LC/UT C)
Spring (T1, 2A, 2B)	1.1/.4	13.0/.8
Channel (T3, 4, 5, 6)	10.8/.1	5.9/.1
Marsh-Open Water (T7, 8, 9A, 9B)	3.0/.2	3.8/<.1
Marsh-Bullrushes (T10A, 10B)	9.7/.1	1.1/.1

Insufficient numbers of Utah chubs were collected to form a good estimation of any activity pattern, although adult Utah chubs were most frequently collected at night. Total catch rates of least chubs for afternoon and nighttime periods is summarized in Table 27. Traps in which fish were captured in low numbers (<10) during all time periods were omitted to eliminate biasing due to low populations. Trapping showed least chubs to be much more active during daylight periods than at night. Catch rates for afternoon periods were 7 to 30 times higher than catch rates for the following night. Trapping was not intensive enough to establish minimum or maximum activity within the daylight-dark periods.

Mark and Recapture

A total of 104 Utah chubs were tagged with numbered fingerling tags during the course of the study (Appendix II). Several were recaptured, but never enough to form population estimates and they were always recaptured in the same spring in which they were tagged.

Least chub were fin clipped at selected areas in the Spring 1 system during September. One hundred thirty-two fish were clipped and then trapped during subsequent time periods. In the southwest arm of Spring 1, 32 of the original 81 fish clipped were recaptured, permitting an estimation of the total population in that area. Using the mark and recapture formula, an estimate of 1012 fish with a standard error of 133 was derived. The only movement of fish observed was one

Table 27. Catch rate (fish/hr.) of least chubs for selected times and sites in the Spring 1 system, July, August, and September 1980.

	Early afternoon (1230-1600)	Late afternoon (1600-2030)	Night (2030-0830)
July			
Trap 4	22.7	7.8	3.7
5	46.0	4.7	2.0
6	13.1	4.8	0.8
8	22.9	35.3	6.9
Mean	26.2	13.2	3.4

	Mid-late afternoon (1400-2000)	Early night (2000-0025)	Late night (0025-0700)
August			
Trap 3	24.0	0.4	4.0
4	25.8	6.2	3.4
5	23.9	7.5	8.0
6	2.3	5.8	0.5
7	9.6	2.1	1.3
8	12.5	0.2	1.9
9A	36.3	4.2	3.1
10A	67.0	2.4	1.0
Mean	25.2	3.6	2.9

Table 27. Continued

	Early afternoon (1100-1630)	Late afternoon (1630-1915)	Night (2000-0730)
September			
Trap 1	71.4	69.6	1.4
2A	10.2	0.4	0
2B	30.0	39.5	0
4	20.2	35.6	0
5	52.4	81.3	5.4
Mean	36.8	45.3	1.4

adult least chub clipped in Spring 1 was captured at Trap 5 in the channel below.

Food Habits

A total of 45 Utah chubs and 30 least chubs were analyzed for stomach contents (Tables 28, 29, and 30). Only one large Utah chub (50 mm) was observed with any significant stomach contents. Smaller Utah chubs (11-50 mm) contained a variety of food items. Zooplankton was the most frequently occurring food item during June and July and often comprised over 90% of the food intake. Four least chub accidentally killed in June were analyzed for stomach contents. These fish were also found to be feeding primarily on zooplankton. Stomach analyses performed on least and Utah chubs collected in August and September showed a pronounced shift in food habits. Both least and Utah diets were found to be composed almost entirely of detritus, filamentous green algae and diatoms.

Reproduction

Only one instance of possible spawning behavior for least chubs was noted. This occurred in June at Spring 4. The difficulty of observing such behavior under the field conditions present was the main reason for the lack of sightings. Numerous least chub males in breeding colaration, however, were observed in June through September. No Utah chubs were observed spawning. One gravid female, however, was collected from Spring 6 in July.

Table 28. Average % volume of food items in diet of Utah chub >50 mm.

Collection site and date	Time	Sample size	Average[1] stomach fullness	Fish with empty stomachs	Bacillariophyta	Chlorophyta	Detritus
Spring 8 6/19/80	2040	2	0	2			
Spring 1 7/17/80	1000	5	0	4			
Spring 1 7/17/80	1015	1	0	1			
Spring 10 9/17/80	1130	2	0.5	1	1.0	60.0	40.0

[1]Includes fish with empty stomachs.

Table 29. Average % volume of food items in diet of Utah chubs <50 mm.

[illegible] site and date	Time	Sample size	Average[1] stomach fullness	Fish with empty stomachs	Bacillariophyta	Chlorophyta	Cyanophyta	Fil. Green Algae	Detritus	Nematoda	Callibaetis	Unidentified Insect Fragments	Orthocladiini	Chydorinae	Cyclops (Adult)	Cyclops (Copepodites)	Cyclops (Nauplii)	Simocephalus	Harpacticoida	Hyallela azteca	Ostracods	Unidentified Zooplankton Frag.	Unidentified Organisms
[illegible]	[illegible]	[illegible]	.7	0	1.1	1.4	0.8				0.1		0.1	92.1	1.0		0.3	4.0	0.1	0.1			0.6
[illegible]	[illegible]	4	.1	1				3.3						17.3	[illegible]8.33								
[illegible]	[illegible]	2	.3	1				5.0							95.0								
[illegible]	[illegible]	3	.3	0	13.3	10.0	0.3		76.7														
[illegible]	[illegible]	8	.2	5	11.7	18.3	2.0		53.3			6.7									3.3	6.7	
[illegible]	1130	10	.5	2	12.3	20.6	0.1		65.6	0.1						1.9	0.1				0.1		

[1]Includes fish with empty stomachs.

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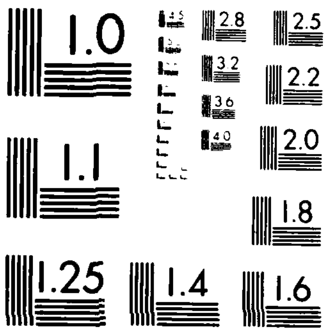

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Table 30. Average % volume of food items in diet of least chubs.

Collection site and date	Time	Sample size	Average[1] stomach fullness	Fish with empty stomachs	*Cricotopus*	*Psectrotanypus*	Dipteran pupae	Hydracarina	*Alona* sp.	*Cyclops*	*Platyias Quadricornis*	Fil. Green Algae	Diatoms	Blue-green	Detritus
Spring 4 6/18/80	1500	4	.5	1	16.6				83.3						
Spring 4 6/19/80	2033	5	.2	3	5.0			<1			2.5	30.0	12.5	2.0	47.5
SW Arm Spring 1 8/21/80	1320	2	.5	0								7.5	45.0		47.5
SW Arm Spring 1 9/18/80	1910	5	.1	4								5.0			95.0
Marsh Below Spring 1 9/18/80	1930	5	1.0	0						<1		9.0	29.0		62.0
Spring 10 8/21/80	1900	5	.5	0		2.0						47.0	2.0		48.0
Spring 10 9/17/80	1130	4	.3	2			2.5		2.5			30.0	<1		65.0

[1]Includes fish with empty stomachs.

DISCUSSION

Water Quality

The Leland Harris Springs complex was composed of a number of different aquatic habitat types. Springs in the area ranged in size from .5 m to 10 m or more in diameter. Some springs occurred as isolated pools with no surface outlets (e.g., Springs 6, 7, 8) while others exhibited measurable flow and were connected with the marsh or pond areas they sustained via distinct channels (e.g., Springs 1 and 5). Springs exhibited cool stable temperatures, relatively low conductivity and only moderate variation in dissolved oxygen. Marsh and pool areas exhibited wide diurnal fluctuations in dissolved oxygen due to their highly productive nature. Extreme daily temperature fluctuations (15-32°) also occurred due to the low volume to surface area ratio of these shallow areas. Hubbs et al. (1967) and Soltz and Naiman (1978) noted similar conditions for other desert spring and marsh systems.

Other water quality parameters measured during this study were relatively uniform and showed the springs to be moderately basic and alkaline with relatively hard water. Chloride and sulphate concentrations were only moderate, as was conductivity. Water quality parameters generally conformed with those reported by Workman et al. (1979) and Crawford (1979) for the area.

Phytoplankton-Periphyton

Phytoplankton communities in Springs 1 and 4 were not markedly different. Densities and species diversity values were roughly comparable though Spring 4 exhibited a much larger peak density in August than Spring 1. Species present included some planktonic forms though most could be characterized as benthic or tychoplanktonic (inhabiting shallow water in association with other vegetation). Species assemblages in the periphyton communities were also relatively similar in Spring 4 and the shelf of Spring 1, and closely resembled the phytoplankton in terms of species present. It is probable that the phytoplankton in fact was composed primarily of components of the periphyton entrained into open water by turbulence or other factors. The primary difference in periphyton communities between Spring 1 and Spring 4 was the lack of any periphyton development in Spring 1 except on the narrow shelf areas of the spring which composed less than 25% of the spring bottom.

Macroinvertebrates and Zooplankton

Benthic macroinvertebrate density and diversity was greater in Spring 4 than Spring 1, a result of the greater number of microniches and higher production in Spring 4 (Margalef 1968). Overall diversity levels were relatively high, particularly in Spring 4, for macroinvertebrate communities in this study. This, however, is somewhat misleading since most of the diversity was in Chironomidae. Chironomid larvae in this study were keyed to genus, a practice which is not yet common (Coffman 1978). Higher diversity values resulted from the subdivision of this taxa which is often treated in the literature only at the family level.

Zooplankton samples collected with a Van Dorn bottle from open water yielded essentially no zooplankton. Net tows made for comparison also yielded no organisms. However, zooplankton were present as evidenced by their presence in fish stomachs. Crawford (Personal communication) indicated that they were occasionally abundant in the marsh below Spring 1. It is probable that predation by the large numbers of fish in the springheads has eliminated zooplankton from the open water areas. In addition, most of the forms collected were types typically inhabiting littoral habitats rather than open water, planktonic areas.

Fish Distribution and Abundance

Populations of least chubs (*Iotichthys phlegethontis*) and Utah chubs (*Gila atraria*) occurred throughout the Leland Harris complex. Most fish were widely dispersed throughout the pond and marsh areas and absent from springheads in June. During July, greatly increased numbers of fish were caught due primarily to the fact that many fish keyed in on the springheads and concentrated in them, thus making them easier to catch and observe instead of being widely dispersed throughout the marshes and ponds. Fish remained concentrated in the springheads during August and September, although some movement away from the springs was noted in September.

The high utilization of springheads by fish in July, August, and September in Study Area 1 was apparently related to extreme temperature and oxygen fluctuations which occurred in the less stable marsh and pond areas. Temperatures in the shallow open waters ranged from lows of 15° C to highs of 32° C. Concentrations of dissolved oxygen approached 0 near dawn, with supersaturation occurring during the day. Factors limiting fish use of the open water areas were apparently high daytime temperatures and low dissolved oxygen concentrations during the night and predawn period. Springheads, by contrast, maintained relatively stable physical environments and provided a refuge from the extremes occurring in open water areas.

Fish usage of Spring 1 also was high during July, August, and September. However, least chubs, particularly young-of-the-year, continued to utilize the outflow channel extensively and marsh areas to a lesser extent. Most fish in marsh areas were found in microhabitats such as among emergent vegetation or along seeps rather than in open water. Both microhabitats apparently modified extremes of the open water areas enough to allow survival of fish. Crawford (1979) noted a similar migration of fish from the marsh below Spring 1 to the springhead although a few fish could always be found in the marsh. She stated that the spring provided relatively constant temperatures, water levels, and chemical conditions but had no cover, inadequate food, limited space, and no vegetation to spawn on. Although the marsh supplied these essentials, it exhibited large chemical and physical fluctuations and was subject to desiccation.

Least chubs exhibited a diurnal activity cycle during this study. Activity as determined by catch rates in traps was apparently light initiated and dark inhibited. Oxygen was not thought to be an important modifying factor in reducing night activity of fish since it remained relatively constant in the springheads. Also, least chub activity was found to be similarly reduced in springheads and marsh areas during the night despite wide differences in the amount of dissolved oxygen fluctuation. Deacon and Minckley (1974) reviewed activity cycles of fish and stated that most desert fish, particularly those living in springs are visually oriented and are thus diurnal. Not enough data were available to construct an activity pattern for Utah chubs, but there were some indications that at least larger Utah chubs might be light inhibited; further research is necessary.

Population Structure and Reproduction

Length-frequency histograms for least chubs for June, July, August, and September show two distinct year classes and a possible third. Those fish under 30 mm total length represented immatures spawned that season. Those between 30 and 50 mm were 1 year old fish; a few fish were caught which measured over 50 mm. These may represent 3 year old fish which is the maximum age that least chubs are reported to attain (Crawford 1979, Workman et al. 1979).

Length-frequency histograms for Utah chubs in June and July presented a more confusing picture primarily due to sample size. Numbers of fish collected and measured in June were relatively small and the length-frequency histogram constructed from it was inadequate to make a good estimate of population structure; only the young-of-the-year show clearly. Larger numbers of Utah chubs were collected in July and, though the length-frequency histograms generated from them was still inadequate to describe the complete population structure, it shows the young-of-the-year class well. Histograms for August and September show the young-of-the-year class as well as one year fish and an undetermined number of older age groups.

The slow increase in average size of recruitment least chubs compared to rapid jumps in size of recruitment Utah chubs can be attributed to the fact the least chub spawn through the entire summer when conditions are favorable (Crawford 1979) and thus the average size of recruitment fish is constantly being influenced by the addition of new young fish. Utah chubs, however, apparently were spawned over a more limited time period and thus average size of the recruitment class increased substantially each month.

Because least chubs spawn inside thick mats of algae and vegetation (Crawford 1979), no least chub were actually observed spawning. However, males which exhibited sexual dimorphism were commonly collected from June through September and a large young-of-the-year class was present. Studies by Crawford (1978, 1979) indicated that peak spawning in Leland Harris Springs complex in 1977 occurred in early May. Intermittent spawning, however, occurred from April through August. Crawford (1979) also stated that least chub have reproductive strategies that are well adapted to Leland Harris. They are not limited by appropriate spawning substrates since they primarily require vegetation. The utilization of live vegetation is an advantage for eggs and larvae since it provides à microenvironment rich in oxygen and food. Also, unlike Utah chubs, least chubs mature in one season and the reproductive effort is such that small numbers of ova are produced for an extended time period. This adaptation allows for larger, stronger larvae produced over an extended time period. Production of young in this manner reduces chance loss of the total recruitment class due to unpredictable environmental fluctuations.

Less information is available on Utah chub reproduction at Leland Harris. Utah chubs apparently spawned over a shorter period than least chubs as indicated by growth of the recruitment class. It is also possible that Utah chubs may reproduce earlier than least chubs though this is uncertain. Crawford (Personal communication) stated that she found no evidence of Utah chubs spawning in the same areas as least chubs (marsh below Spring 1). She speculated that Utah chubs might be spawning in waters with better water quality.

Food Habits

Only one large (50 mm+) Utah chub contained any significant amount of food. The low incidence of large Utah chubs feeding is a probable reflection of low sample size and the fact that large Utah chubs occurred in springheads where food was often limited.

Diet of smaller Utah chubs (<50 mm) and least chubs was almost identical for each month studied. Fish collected in June and July fed almost exclusively on zooplankton though limited amounts of algae were also consumed. However, in August and September, least and Utah chub diets consisted of only small amounts of zooplankton and insects. Primary food items were long strands of filamentous green algae, diatoms, and detritus. Workman et al. (1979) reported a similar shift in diet for Utah chubs in 38 desert springs from spring to summer. In addition, he collected 48 least chubs from the Leland Harris complex between July and January in which he found zooplankton, chironomids, and diatoms to be important dietary components. Leser and Deacon (1968) also reported shifts in diet during the summer for Nevada pupfish. Algae and crustaceans dominated during the spring, algae in the summer, and gastropod molluscs in the fall. Organic and inorganic debris (detritus) were present throughout the year but significantly so in the summer. Deacon and Minckley (1974) summarized findings of other authors and stated the relatively heavy use of indigestable algae in at least Cyprinodon nevadensis nevadensis may be the result of a scarcity of other foods or other factors that place the fish under nutritional stress.

Stomach analyses performed on least chubs collected at the same time from the southwest arm of Spring 1 and the marsh below showed that fish in the springhead with an average stomach fullness of .1 had essentially not been feeding. Least chubs collected in the marsh exhibited an average stomach fullness of 1.0. Diet was approximately 50% filamentous green algae and 50% detritus.

Least and Utah chubs in the Leland Harris complex were basically opportunistic feeders. Diets of the fish were probably related to seasonal changes in the abundance or availability of food items. Lack of feeding by some fish in relatively sterile springheads without periphyton development can best be attributed to simply the lack of food in these areas. Crawford (1979) similarly stated that Spring 1 provided refuge for fish during certain periods but was devoid of food.

Diets of least and Utah chubs in this study evidenced a great deal of overlap. Hynes (1970) indicated that when species of fish exhibit very similar diets, they are often not directly competing since that food resource is generally present in non-limiting amounts.

RECOMMENDATIONS

Management

1. Fencing of the area around Spring 1 is strongly recommended. Spring 1 contains one of the largest known populations of least chubs in the complex during the summer. Bank damage resulting from livestock is extensive and should be controlled.
2. Introduction of any exotic species such as largemouth bass should be discouraged as much as is possible. The relative isolation of the area should be an advantage in this respect.
3. Any active withdrawal of water or lowering of water levels in the complex should be discouraged until specific studies are made to ascertain the impact of such withdrawals.

Research

1. Continuation of baseline data gathering on a seasonal basis until a minimum of one year of data is obtained.
2. Based on information gathered in baseline studies, field studies should be designed which specifically test hypotheses concerning activity patterns and competition between least chubs and Utah chubs and which test the factors controlling their distribution within the Leland Harris complex. Design of studies to examine critical areas in such a fashion will

allow the use of statistics as a quantitative tool rather than as a descriptive one, a case in which test statistics are usually inappropriate.

3. Further searches for other areas containing least chubs is encouraged. We consider the report by Workman et al. (1979) to be insufficient in this respect.

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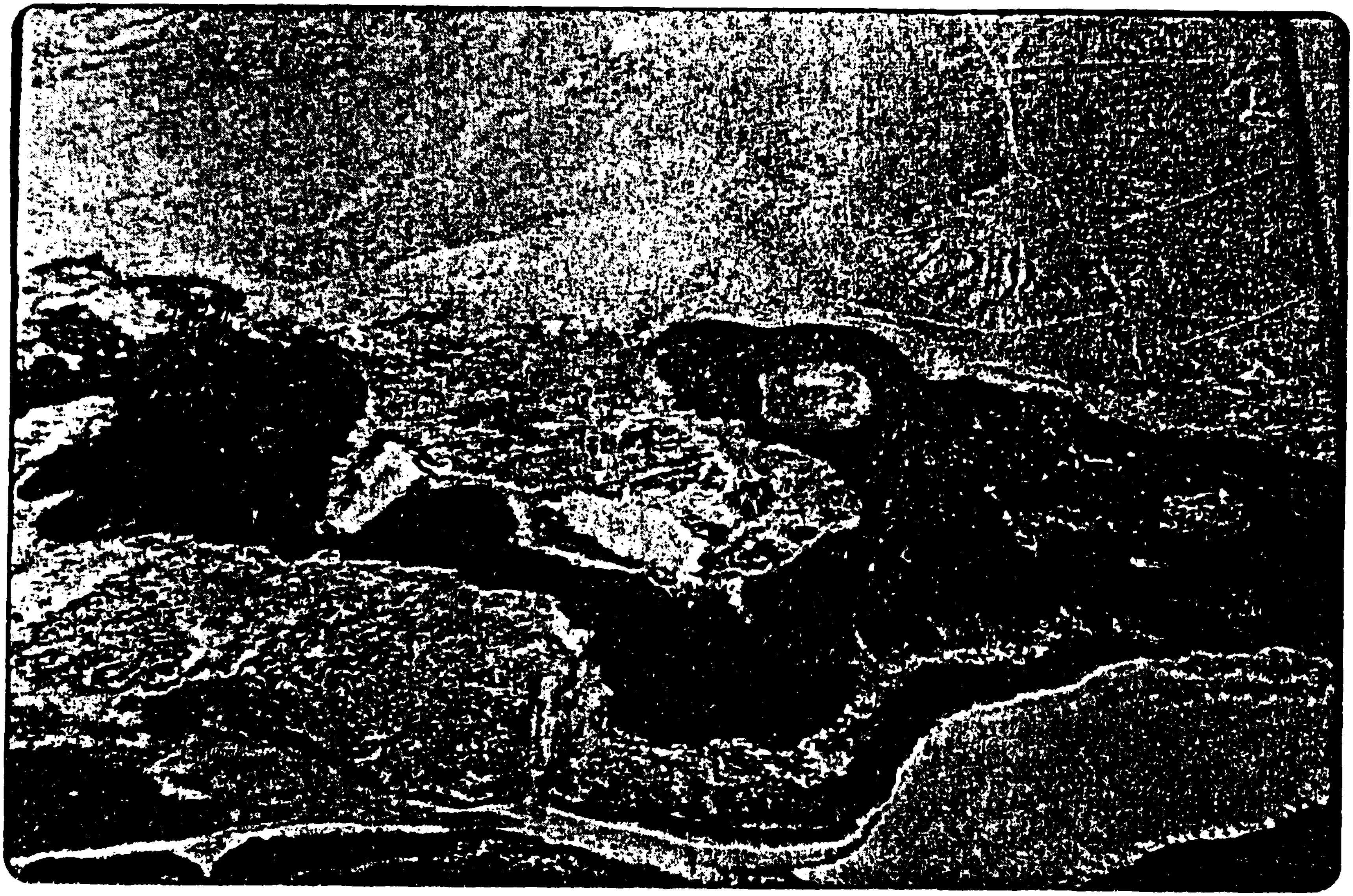
APPENDIX I



Overview of Leland Harris Complex Showing Location of Study Areas 1 and 2

Infrared Photo of Study Area 1[1] and Surrounding Marsh

[1]View of sample plot is distorted slightly due to camera angle.

Infrared Photo Showing Spring 1 and Associated Areas in Study Area 2

APPENDIX II

LIST OF TAGGED FISH

Species	Length	Collection site	Tag No.
<u>July</u>			
Utah Chub	106	Spring 6	801
"	99	"	802
"	68	"	804
"	88	"	805
"	98	Spring 8	878
"	115	"	879
"	83	"	880
"	92	"	881
"	88	"	882
"	89	"	883
"	94	"	884
"	81	"	885
"	95	"	886
"	93	"	887
"	86	"	888
"	94	"	889
"	95	"	890
"	107	"	891
"	115	"	892
"	119	"	893
"	92	"	894
"	107	"	896
"	90	"	897

List of Tagged Fish (Continued)

Species	Length	Collection site	Tag No.
July (continued)			
Utah Chub	100	Spring 8	898
"	105	"	899
August			
Utah Chub	100	Spring 1	600
"	106	"	613
"	104	"	650
"	112	"	660
"	105	"	661
"	112	"	683
"	90	"	807
"	110	"	852
"	97	"	853
"	109	"	854
"	94	"	857
"	89	"	861
"	131	Spring 2	855
"	78	Spring 5-B	850
"	73	"	868
"	73	"	869
"	72	"	870
"	77	"	871
"	94	"	872

List of Tagged Fish (Continued)

Species	Length	Collection site	Tag No.
August (continued)			
Utah Chub	75	Spring 5-B	873
"	72	"	874
"	86	"	875
"	85	"	876
"	95	Spring 6	858
"	84	"	859
"	97	"	860
"	89	"	862
"	89	"	863
"	86	Spring 8	864
"	95	"	865
"	102	"	866
"	87	"	888
September			
Utah Chub	87	Spring 1	616
"	100	"	620
"	86	"	628
"	93	"	632
"	95	"	636
"	74	"	639
"	77	"	641

List of Tagged Fish (Continued)

Species	Length	Collection site	Tag No.
September (continued)			
Utah Chub	95	Spring 1	646
"	100	"	665
"	111	"	668
"	78	"	685
"	80	"	698
"	110	"	827
"	92	"	831
"	84	"	835
"	103	"	836
"	108	"	838
"	93	Spring 5	811
"	92	"	812
"	82	"	813
"	76	"	814
"	95	"	815
"	88	"	816
"	79	"	817
"	83	"	818
"	77	"	819
"	80	"	820
"	81	"	821

List of Tagged Fish (Continued)

Species	Length	Collection site	Tag No.
September (continued)			
Utah Chub	76	Spring 5	830
"	80	"	850
"	91	"	808
"	84	"	809
"	95	"	810
"	81	"	832
"	84	"	833
"	80	"	851
"	77	"	856
"	105	Spring 8	822
"	101	"	823
"	97	"	824
"	93	"	825
"	86	"	826
"	99	Spring 10	631
"	73	"	679
"	84	"	691
"	71	"	828
"	93	"	829

APPENDIX III

PARTIAL VERTEBRATE SPECIES LIST FOR LELAND HARRIS SPRINGS COMPLEX

	Common Name	Scientific Name
Reptiles		
c[1]	Northern Black Racer	Coluber constrictor constrictor
c	Wandering Garter Snake	Thamnophis elegans vagrans
o	Great Basin Gopher Snake	Pituophis melanoleucus deserticola
Amphibians		
c	Northern Leopard Frog	Rana pipiens

[1]o - occasional; c - common.

APPENDIX C

INDIRECT EFFECTS INDEX FOR IMPACT ANALYSIS

Many impacts of development projects are caused not by the construction or operation or the project itself but by the long- or short- term population increases associated with the project. These indirect impacts would include increased pressure on hunting, fishing and other recreational resources, and cannot be easily predicted. A model to estimate these indirect impacts has been developed to assess effects of population growth on recreation and use of natural landscape.

Dyer and Whaley (1968) developed a model for predicting use of recreation sites. They attempted to account for distance from origin to recreation site, competing facilities, degree of urbanization of origin, age, occupation and income of the people. Regression models using parts of their general model were able to account for up to 74 percent of the variance about predictions of stream use, and 57 percent of the variance about prediction of campground use.

However, a regression model is inadequate for prediction of future use if no history of use is available. It is possible to develop a theoretical model that will be sensitive to population levels and distribution of impacts about population centers. Impacts around population centers are expected to decrease with distance and two general distributions are most frequently used: gravity models and normal distributions. Gravity models are based on the assumption that influence of a population center falls off as the inverse square of distance (Reilly 1929, Huff 1963). These models can be modified to incorporate intervening opportunities. This analysis is founded on the assumption that recreation impacts about a population center would be normally distributed with distance, rather than an inverse square relation.

The model developed and a preliminary validation of it are discussed below. The model is applied to analysis of potential indirect impacts of operating base (OB) sites in the Nevada/Utah M-X project area. Five sites have been selected for possible OB sites in seven alternative combinations of two bases each. The model is used to evaluate the potential indirect effects of the base pairs in each alternative.

THE MODEL

Assumptions

The model is based on the general assumption that all measurable impacts would be normally distributed about the OB centers. That is, one would expect a bell-shaped distribution of impacts. Second, it is assumed that most of the impact would occur within 100 air miles from the OB site. Third, the degree of impact is proportional to the population of the OB site. And finally, certain resources attract more people than others. That is, people are willing to travel farther to visit some areas than others. The model takes these assumptions into account.

The model gives an index of effect described by a nonlinear function of distance that is a modified form of the Normal (μ,σ) density function. This model has a mean of zero and a standard deviation of 35. Thus, approximately 68 percent of the population-related indirect impacts would occur within 35 mi (one standard deviation), 95 percent of the impacts would occur within 70 mi, and 99 percent of the impact related to a given OB site within 105 mi.

The function is adjusted to OB population levels by the simple expedient of multiplying the normalized function by the OB population. A perhaps more realistic approach would have been to quantify the population density (humans per hectare), and model that population density directly. However, for several reasons, this procedure was not possible and would have required many more assumptions that could not be validated. The function developed is an index relating the distribution of the population impacts to population size, but cannot be construed as an estimate of the population density at any point. This approach gives an effect index that varies by many orders of magnitude. Close to the population center of say 20,000 people, the index will approach 20,000, and will approach 0 at the 4th standard deviation from the population center.

It is also necessary to account for the attractiveness of resources. This is easily done by multiplying the standard deviation, σ, by a factor, called the appeal rating, which takes values of 1, 2, or 3 and is based on travel distance to the resource. If a resource has an appeal such that a person would travel up to 200 mi solely to visit it, it would be given an appeal rating of 2. If a person would travel 300 mi or more to visit that resource, then the appeal rating is 3. Otherwise the appeal rating is 1. This has the effect of doubling or tripling the spread of the function. The appeal rating is relatively easy to assess. Lake Mead, for example, has an obvious appeal rating of 3 since many people travel up to 300 mi to use Lake Mead's recreational resources. Wheeler Peak has been assigned an appeal rating of 2, but if it should become part of a national park and thus receive greater publicity, the rating might be upgraded.

The Equations

The effect index for a single population center j on resource i is given by equation 1 below:

$$E_{ij} = \exp\left[-\frac{1}{2}\left(\frac{X_{ij} - \mu}{\sigma A_i}\right)^2\right] P_j$$

where

E_{ij} = Effect index of OB j on resource i.

X_{ij} = Distance from OB site j to resource i.

μ = Mean of distribution (μ=0).

σ = Primary Primary standard deviation of the function (σ=35).

P_j = Long term population of OB.

A_i = Appeal rating

Equation 1, evaluated for several population levels and 120 mi is illustrated in Figure C-1. Because the basing alternatives call for two bases, it is possible that their influence will overlap. This is given by evaluating equation 1 for both OB sites and summing (Figure C-2). A combined effect index using the mean distance (equation 2) is used for most of the analyses discussed below:

$$E_{ik} = \sum_{j=1}^{2} \exp\left[-\frac{1}{2} \left(\frac{\bar{x}_{ij} - \mu}{\sigma A_i} \right)^2 \right] P_j$$

where

E_{ik} = Combined effect index of Alternative k on resource i.

$\bar{x}_{ij}$ = Mean distance of resource i from OB siting.

All other symbols same as in equation (1).

As pointed out above, this index is an ordinal ranking index for use in estimating the relative impacts of a given population center on a specific resource. While the numbers vary by many orders of magnitude, a difference of five orders of magnitude implies that the site with the higher value will be more heavily impacted but does not imply that one site is five times as heavily impacted as another. In fact, it may well be that only very large effect indexes are significant for most resources. Perhaps the best way to view the effect index is as an independent variable in regression analysis. This is discussed below.

VALIDATION

The model was tested using the results of a survey of fishing preferences by the State of Nevada (Anon. 1979). These data provided estimates of the number of anglers, angler days, and county of origin. Appeal ratings were assigned to 69 streams and 60 lakes, and effect indices were computed for each fishing site relative to home county using equation (1). These raw data are given in Table C-1.

The appeal rating of the specific resource was initially assigned without reference to the perceived appeal of the user. Appeal was ranked on a relative use criteria, using all fishing data aggregated. Resource rank was assigned as follows: (1) resources with users from only one county; (2) resource sites with users from more than one county and with no county contributing more than 1,000 anglers, and (3) resource sites with one or more counties contributing more then 1,000 anglers to the angler use total. Through initial analysis it was found that the assumption of appeal-index assignment without regard to the availability of a like-resource near the population source did not accurately reflect user preference. The appeal ratings were then modified to more closely reflect county by county use data. No hard and fast criteria, like those initially used, were set. Appeal ratings were varied by inspecting raw use data and calculated residual values, as well as the knowledge of local resource availabilities. Further modification of appeal indices, based on attempts to minimize residual values, did not enhance the predictive value of the model or statistical significance of results.

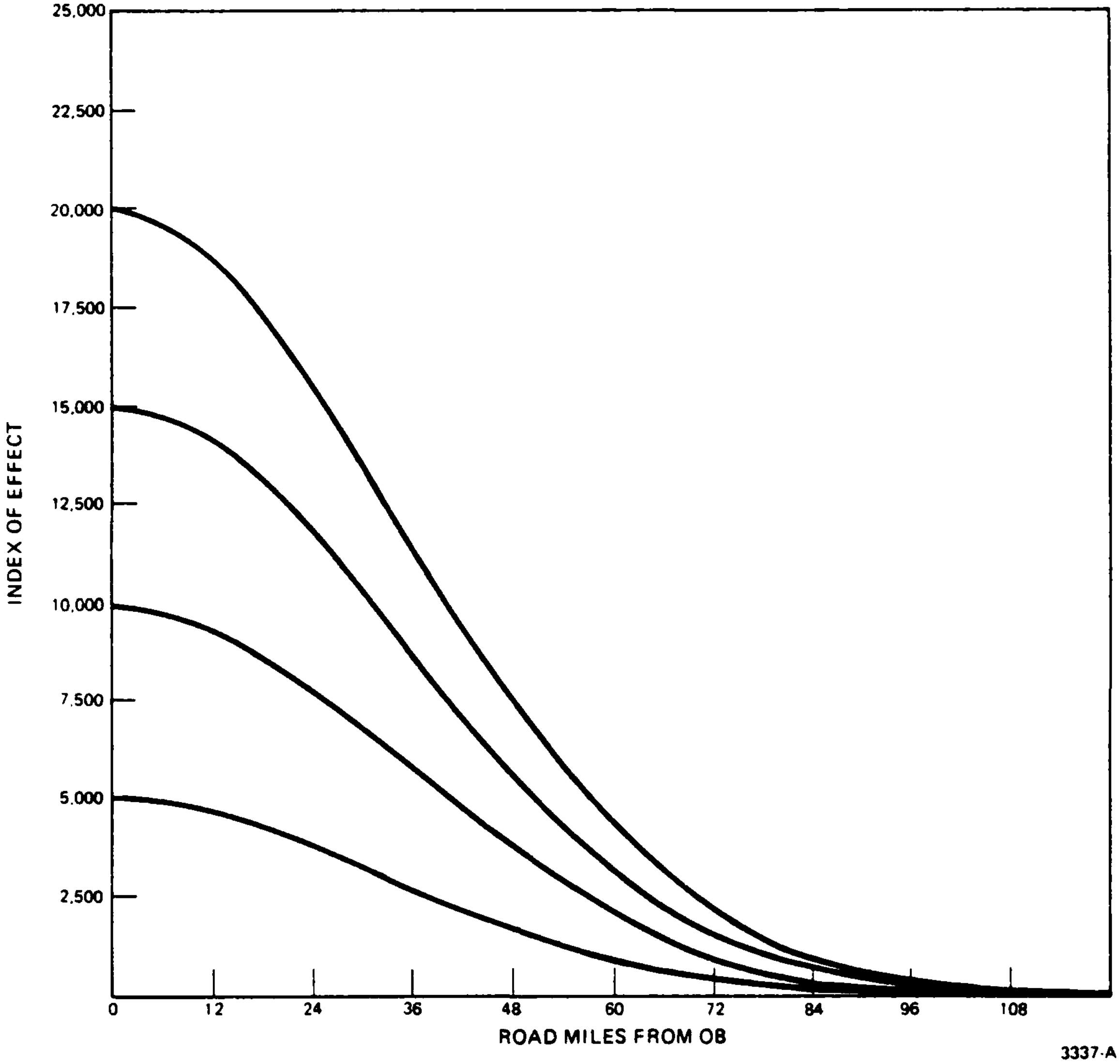


Figure C-1. Effect index plotted against distance from hypothetical population centers. The curves from top to bottom reflect populations of 20,000, 15,000, 10,000 and 5,000 people.

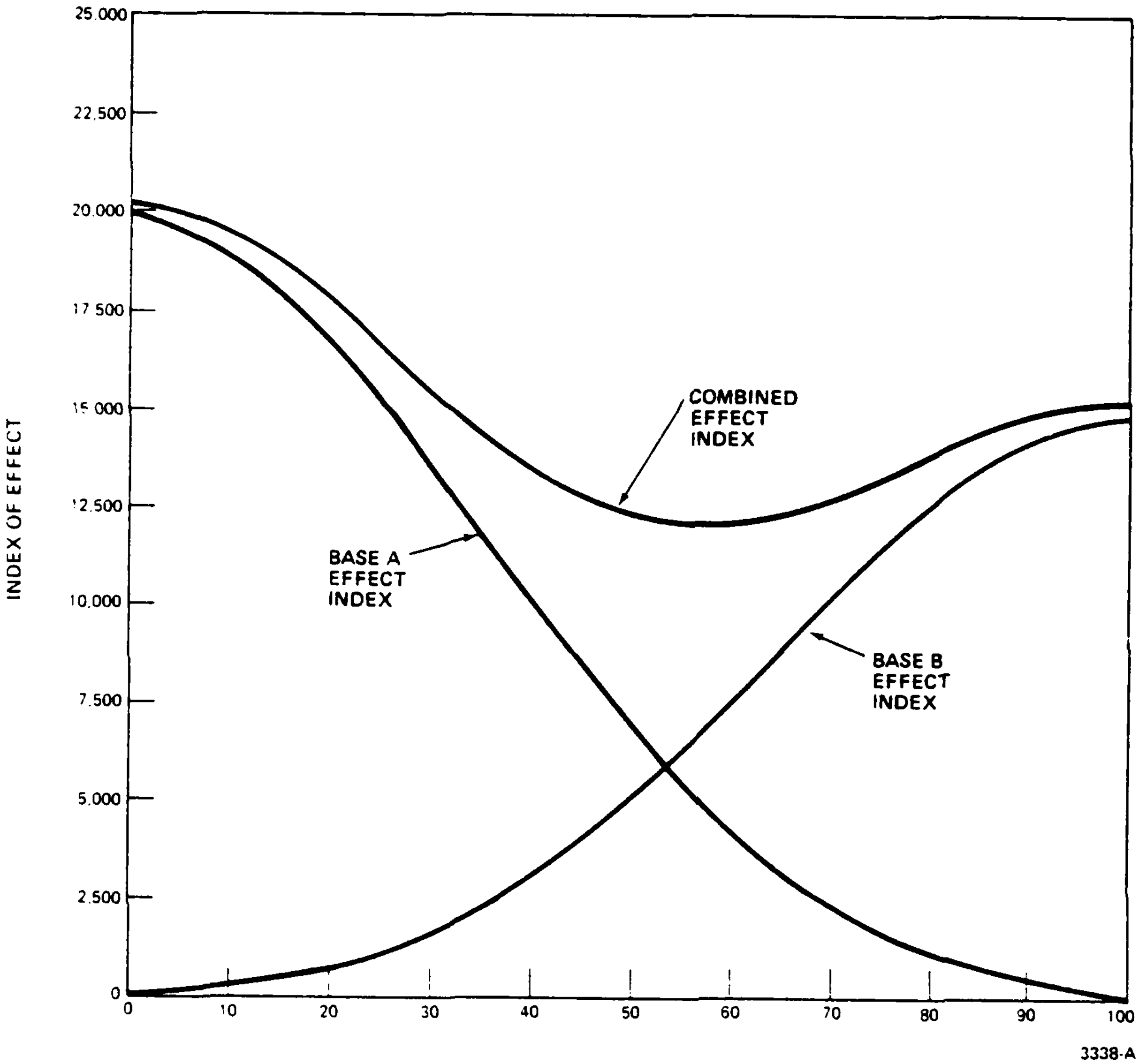


Figure C-2. Effect indexes of two hypothetical population centers 100 miles apart, Base A: 20,000 people; Base B: 15,000 people. The combined index is given by equation 2 in text.

Table C-1. Data used for validation of effects index model (page 1 of 2).

USE OF FISHING STREAMS IN NEVADA

ID	STREAM	APPEAL	HOME CNTY	HOME POP	DIST	ANGLERS	ANGLRDAY	EFFINDX
1012	BAKER CK	3 0	CLARK	376800 0	210 0	207 0	1170 0	4155 9
1012	BAKER CK	3 0	LANDER	3400 0	182 0	10 0	14 0	757 0
1012	BAKER CK	3 0	LYON	11100 0	268 0	22 0	37 0	427 2
1012	BAKER CK	3 0	WHITE PINE	9300 0	37 6	97 0	493 0	8722 4
1013	BAKER CK SF	3 0	CLARK	376800 0	210 0	110 0	186 0	50994 3
1019	BASTIAN CK	1 0	WHITE PINE	9300 0	13 4	37 0	32 0	3099 7
1025	BERRY CK,LWR	2 0	CLARK	376800 0	234 0	45 0	110 0	1411 1
1025	BERRY CK,LWR	2 0	WASHOE	163200 0	276 0	3 0	45 0	68 7
1025	BERRY CK LWR	2 0	WHITE PINE	9300 0	21 6	118 0	227 0	6867 6
1026	BERRY CK NF	1 0	WHITE PINE	9300 0	14 4	20 0	120 0	3545 3
1033	BIRD	2 0	MINERAL	5500 0	228 0	5 0	6 0	27 3
1033	BIRD	2 0	WHITE PINE	9300 0	11 2	88 0	397 0	9181 7
1084	CAVE CK	2 0	CLARK	376800 0	218 0	65 0	275 0	2951 5
1084	CAVE CK	2 0	LINCOLN	3300 0	100 0	4 0	60 0	1189 5
1084	CAVE CK	2 0	WHITE PINE	9300 0	13 6	97 0	112 0	9126 1
1074	CLEVE CK	2 0	CHURCHILL	12400 0	228 0	55 0	68 0	61 6
1074	CLEVE CK	4 0	CLARK	376800 0	224 0	275 0	560 0	104764 5
1074	CLEVE CK	2 0	ELKO	15000 0	130 0	10 0	1 0	2674 0
1074	CLEVE CK	2 0	LINCOLN	3300 0	102 0	17 0	119 0	1141 4
1074	CLEVE CK	2 0	WASHOE	163200 0	234 0	22 0	4 0	43 5
1074	CLEVE CK	1 0	WHITE PINE	9300 0	16 0	8 0	49 0	8377 3
1112	CURRANT CK	2 0	CLARK	376800 0	192 0	58 0	110 0	8759 0
1112	CURRANT CK	2 0	NYE	6500 0	72 0	24 0	155 0	2829 8
1112	CURRANT CK	2 0	WHITE PINE	9300 0	40 0	33 0	14 0	7899 1
1133	DUCK CK	2 0	CLARK	376800 0	226 0	3 0	192 0	2054 2
1133	DUCK CK	2 0	NYE	6500 0	120 0	59 0	17 0	1495 4
1133	DUCK CK	2 0	WASHOE	163200 0	278 0	30 0	85 0	61 4
1133	DUCK CK	2 0	WHITE PINE	9300 0	18 4	96 0	582 0	8994 2
1136	EAST CK	1 0	WHITE PINE	9300 0	20 8	78 0	6 0	7794 6
1187	HUNTINGTON CK	2 0	CLARK	376800 0	272 0	3 0	55 0	196 4
1187	HUNTINGTON CK	1 0	ELKO	15000 0	58 0	10 0	12 0	3800 0
1190	ILLIPAH CK	1 0	ELKO	15000 0	106 0	1 0	1 0	152 9
1190	ILLIPAH CK	2 0	EUREKA	900 0	34 0	39 0	1 0	711 0
1190	ILLIPAH CK	2 0	ORMSBY,CARSN C	29500 0	240 0	4 0	39 0	82 6
1190	ILLIPAH CK	2 0	WASHOE	163200 0	242 0	24 0	52 0	414 4
1190	ILLIPAH CK	2 0	WHITE PINE	9300 0	28 0	86 0	137 0	8585 0
1215	KALAMAZOO CK	3 0	CLARK	376800 0	246 0	106 0	460 0	24221 1
1215	KALAMAZOO CK	1 0	LINCOLN	3300 0	128 0	6 0	21 0	4 1
1215	KALAMAZOO CK	1 0	NYE	6500 0	135 0	8 0	3 0	2 7
1215	KALAMAZOO CK	3 0	WHITE PINE	9300 0	27 2	142 0	659 0	5993 1
1226	LEHMAN CK	3 0	CLARK	376800 0	220 0	351 0	387 0	41959 4
1226	LEHMAN CK	3 0	LINCOLN	3300 0	86 0	48 0	13 0	2359 6
1226	LEHMAN CK	3 0	WASHOE	163200 0	310 0	67 0	270 0	2089 0
1226	LEHMAN CK	3 0	WHITE PINE	9300 0	41 6	121 0	1796 0	8598 0
1250	MOODY CK	1 0	WHITE PINE	9300 0	20 8	19 0	22 0	7794 6
1290	PIERMONT CK	1 0	WHITE PINE	9300 0	21 6	15 0	30 0	7687 4
1359	SILVER CK	1 0	CLARK	376800 0	222 0	57 0	115 0	0 0
1359	SILVER CK	3 0	MINERAL	5500 0	248 0	7 0	4 0	338 1
1359	SILVER CK	3 0	WHITE PINE	9300 0	36 8	135 0	1493 0	8746 0
1372	SNAKE CK	4 0	CLARK	376800 0	212 0	655 0	1935 0	119723 4
1372	SNAKE CK	3 0	ESMERALDA	700 0	130 0	10 0	12 0	161 0
1372	SNAKE CK	3 0	LINCOLN	3300 0	80 0	35 0	156 0	2468 7
1372	SNAKE CK	3 0	WHITE PINE	9300 0	42 4	84 0	1556 0	5571 8
1393	STEPTOE CK	2 0	CLARK	376800 0	213 0	10 0	55 0	2951 5
1393	STEPTOE CK	2 0	LINCOLN	3300 0	100 0	3 0	50 0	1189 5
1393	STEPTOE CK	2 0	NYE	6500 0	112 0	16 0	17 0	1807 2
1393	STEPTOE CK	3 0	WHITE PINE	9200 0	8 8	189 0	765 0	9267 4
1397	STRAWBERRY CK	1 0	WHITE PINE	9300 0	36 8	82 0	80 0	5350 9
1406	TAFT CK	2 0	CLARK	376800 0	232 0	8 0	110 0	1551 9
1406	TAFT CK	2 0	WHITE PINE	9300 0	20 8	19 0	16 0	8898 4
1424	TIMBER CK	2 0	CLARK	376800 0	236 0	3 0	55 0	1232 0
1424	TIMBER CK	2 0	WHITE PINE	9200 0	16 8	150 0	699 0	9131 7
1457	WHITE RIVER	3 0	CLARK	376800 0	200 0	113 0	495 0	61415 1
1457	WHITE RIVER	2 0	ELKO	15000 0	126 0	3 0	3 0	2272 1
1457	WHITE RIVER	2 0	LINCOLN	3300 0	98 0	2 0	6 0	1238 5
1457	WHITE RIVER	2 0	NYE	6500 0	79 0	4 0	3 0	3493 8
1457	WHITE RIVER	2 0	WASHOE	163200 0	250 0	5 0	4 0	277 3
1457	WHITE RIVER	3 0	WHITE PINE	9300 0	32 8	148 0	331 0	8857 1
1475	WILLOW CK	1 0	WHITE PINE	9300 0	14 4	63 0	40 0	6545 3

Table C-1. Data used for validation of effects index model (page 2 of 2).

USE OF LAKES IN NEVADA

ID	STREAM	APPEAL	HOME CNTY	HOME POP	DIST	ANGLERS	ANGLRDAY	EFFINDX
3002	ADAMS-MCGILL	3.0	CLARK	376800.0	160.0	368.0	3269.0	115003.8
3002	ADAMS-MCGILL	3.0	EUREKA	800.0	94.0	26.0	16.0	535.9
3002	ADAMS-MCGILL	3.0	LINCOLN	3300.0	58.0	110.0	367.0	2823.1
3002	ADAMS-MCGILL	1.0	MINERAL	5500.0	196.0	14.0	35.0	0.0
3002	ADAMS-MCGILL	2.0	NYE	6500.0	70.0	97.0	369.0	3942.4
3002	ADAMS-MCGILL	1.0	PERSHING	3000.0	295.0	4.0	22.0	0.0
3002	ADAMS-MCGILL	1.0	WASHOE	163200.0	270.0	6.0	4.0	0.0
3002	ADAMS-MCGILL	4.0	WHITE PINE	9300.0	63.2	653.0	5211.0	8399.1
3009	BAKER LA	1.0	WHITE PINE	9300.0	37.5	33.0	43.0	5222.5
3041	CAVE LA	1.0	CHURCHILL	12400.0	224.0	7.0	8.0	0.0
3041	CAVE LA	4.0	CLARK	376800.0	220.0	1779.0	3944.0	109620.1
3041	CAVE LA	1.0	ELKO	15000.0	130.0	4.0	33.0	15.1
3041	CAVE LA	2.0	EUREKA	800.0	72.0	14.0	16.0	471.4
3041	CAVE LA	2.0	LINCOLN	3300.0	102.0	88.0	187.0	1141.4
3041	CAVE LA	3.0	MINERAL	5500.0	220.0	42.0	100.0	612.5
3041	CAVE LA	1.0	NYE	6500.0	116.0	31.0	48.0	26.9
3041	CAVE LA	3.0	ORMSBY,CARSN C	29500.0	275.0	66.0	263.0	886.4
3041	CAVE LA	1.0	PERSHING	3000.0	219.0	4.0	55.0	0.0
3041	CAVE LA	1.0	STOREY	1200.0	266.0	11.0	4.0	0.0
3041	CAVE LA	2.0	WASHOE	163200.0	230.0	183.0	507.0	54.7
3041	CAVE LA	5.0	WHITE PINE	9300.0	11.2	1360.0	8113.0	9281.0
3051	COMINS LA	1.0	CHURCHILL	12400.0	220.0	11.0	8.0	0.0
3051	COMINS LA	2.0	CLARK	376800.0	216.0	976.0	2018.0	3224.9
3051	COMINS LA	3.0	DOUGLAS	14300.0	274.0	33.0	190.0	474.9
3051	COMINS LA	1.0	ELKO	15000.0	128.0	17.0	47.0	18.7
3051	COMINS LA	1.0	ESMERALDA	700.0	160.0	8.0	11.0	0.0
3051	COMINS LA	1.0	EUREKA	800.0	68.0	27.0	24.0	121.2
3051	COMINS LA	1.0	HUMBOLDT	7600.0	196.0	10.0	69.0	0.0
3051	COMINS LA	1.0	LINCOLN	3300.0	100.0	20.0	149.0	55.7
3051	COMINS LA	3.0	MINERAL	5500.0	214.0	66.0	179.0	689.2
3051	COMINS LA	1.0	NYE	6500.0	110.0	23.0	26.0	46.6
3051	COMINS LA	4.0	ORMSBY,CARSN C	29500.0	272.0	162.0	277.0	4468.5
3051	COMINS LA	1.0	WASHOE	163200.0	274.0	6.0	90.0	0.0
3051	COMINS LA	4.0	WHITE PINE	9300.0	7.2	743.0	4993.0	9237.7
3116	HAYMEADOW RS	3.0	CLARK	376800.0	156.0	359.0	14020.0	124965.9
3116	HAYMEADOW RS	1.0	ESMERALDA	700.0	120.0	4.0	16.0	2.0
3116	HAYMEADOW RS	1.0	LANDER	3400.0	192.0	10.0	12.0	0.0
3116	HAYMEADOW RS	1.0	LINCOLN	3300.0	58.0	38.0	165.0	836.0
3116	HAYMEADOW RS	2.0	WHITE PINE	9300.0	66.4	264.0	1544.0	5930.6
3130	ILLIPAH RES	1.0	CLARK	376800.0	228.0	114.0	477.0	0.0
3130	ILLIPAH RES	3.0	EUREKA	800.0	34.0	40.0	112.0	759.1
3130	ILLIPAH RES	2.0	LINCOLN	3300.0	122.0	48.0	26.0	722.6
3130	ILLIPAH RES	1.0	WASHOE	163200.0	242.0	51.0	180.0	0.0
3130	ILLIPAH RES	4.0	WHITE PINE	9300.0	27.2	733.0	2574.0	9126.1
3025	RUBY MARSH	3.0	CHURCHILL	12400.0	190.0	118.0	230.0	2412.1
3025	RUBY MARSH	4.0	CLARK	376800.0	292.0	610.0	1481.0	42803.2
3025	RUBY MARSH	4.0	DOUGLAS	14300.0	254.0	214.0	429.0	2757.8
3025	RUBY MARSH	5.0	ELKO	15000.0	46.0	1883.0	13607.0	14490.6
3025	RUBY MARSH	3.0	ESMERALDA	700.0	188.0	12.0	136.0	140.9
3025	RUBY MARSH	3.0	EUREKA	800.0	62.0	34.0	408.0	672.0
3025	RUBY MARSH	3.0	HUMBOLDT	7600.0	126.0	146.0	513.0	3699.3
3025	RUBY MARSH	3.0	LANDER	3400.0	88.0	196.0	746.0	2393.1
3025	RUBY MARSH	3.0	LINCOLN	3300.0	188.0	75.0	192.0	664.3
3025	RUBY MARSH	1.0	LYON	11100.0	202.0	3.0	290.0	0.0
3025	RUBY MARSH	1.0	MINERAL	5500.0	212.0	30.0	70.0	0.0
3025	RUBY MARSH	3.0	NYE	6500.0	154.0	127.0	369.0	2217.2
3025	RUBY MARSH	4.0	ORMSBY,CARSN C	29500.0	242.0	374.0	794.0	6622.1
3025	RUBY MARSH	1.0	PERSHING	3000.0	164.0	15.0	132.0	0.1
3025	RUBY MARSH	5.0	WASHOE	163200.0	244.0	1559.0	6574.0	51741.7
3025	RUBY MARSH	4.0	WHITE PINE	9300.0	34.0	745.0	7218.0	7768.0

Stepwise regressions were run on the data using models: $y=a+bE+cE^2+dE^3$. The regression coefficients and some statistics are given in Table C-2. The effect index alone was sufficient to account for up to 65 percent of the variance about the prediction of number of anglers on a given stream or lake. A distance times effect index cross product was included to predict angler days from effect index. The rationale for this step was that people would be more inclined to camp at more distant sites, giving a larger ratio of angler days to anglers.

Equations 4-8 in Table C-2 were obtained by adjusting the appeal rating for intervening opportunities. Fishermen tend not to bypass nearby high-appeal streams for one more distant. The representation of appeal rating as A(jj)* was the only change made in equation 1. It would be possible to modify equation 1 to better predict angler days. Also, there were differences between the use of lakes and streams. However, the results presented indicate that the model could be used to generate predictions of resource use and environmental impacts.

ANALYSIS OF OB SITING ALTERNATIVES

Input Data

The long-term population figures for operating bases used in the analysis were computed using the October 15, 1980 estimates used throughout the DEIS (ETR-2, ETA-28). These estimates have increased slightly since then, but the difference is not great enough to significantly change the output of the model. Population estimates were provided by county for each of the six Nevada/Utah alternatives and the Proposed Action. Two options were provided using two different baseline populations. One used extrapolated concurrent population growth with M-X as well as the other large future projects expected in the same counties. The other option *used normal extrapolation of past growth* and project increase due to the M-X project only. The latter option was used because the population estimates were higher and provided the so-called worst case analysis.

For each project alternative, baseline population and projected increase for the counties affected by the first and second OBs from the start of project construction in 1982 to the end of the construction and into a stabilized operations period by 1994 are given in Table C-3. The 1994 projected population increase for the directly affected OB county was assumed to indicate the permanent operation personnel numbers (i.e., long-term population) at the bases.

Distances were measured from the center of each OB site to the nearest and farthest points in each hydrologic subunit. Appeal ratings were subjectively assigned to recreation and potential wilderness areas. Consultations with state agencies, BLM, and other knowledgeable personnel were used in estimating appeal ratings. The appeal ratings ranged from 1 to 3 as discussed above. The "attractants" were first sorted out by hydrologic subunits using existing tables and distribution maps. The highest rating determined for any "attractive" area in a given watershed was then assigned to that watershed. This was done for all watersheds.

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*Parenthentic notation = subscript

Table C-2. Regression equations and some statistics pertaining to prediction of anglers and angler days from effect index.

	Equation	F Ratio	R^2
1.	$A_s = 22.1 + 0.0067E$	66.5 ***	0.50
2.	$A_l = 42.2 + 0.045E - 4.2 \times 10^{-7}E^2$	21.5 **	0.43
3.	$A_{ds} = 105 + 0.023E$	30.6 **	0.31
4.	$A_{dl} = 738.6 + 0.071E$	24.2 **	0.29
5.	$A_s = 29.6 + 0.0038E'$	126.1 ***	0.65
6.	$A_l = 71.3 + 0.051E' - 3.6 \times 10^{-7}E'^2$	46.05 ***	0.62
7.	$A_{ds} = 67.3 + 0.043E' - 2.4 \times 10^{-5} E'D$	16.13 *	0.33
8.	$A_{dl} = -48.3 + 0.66E' - 4.2 \times 10^{-6}E'^2 - 0.0016E'D$	42.47 **	0.45

T3962/10-2-81

A_s = Number of anglers fishing a given stream.

A_l = Number of anglers fishing a given lake.

A_{ds} = Angler days on streams.

A_{dl} = Angler days on lakes.

E = Effect index using a single appeal rating for each stream/lake.

E' = Effect index using adjusted appeal rating.

D = Air distance from home county to stream/lake.

* = Significant at P = 0.01.

** = Significant at P = 0.005.

*** = Significant at P = 0.001.

Table C-3. OB site long-term population.

Alternative	Base A	Population	Base B	Population
0	Coyote	15,967	Milford	13,071
1	Coyote	15,967	Beryl	12,834
2	Coyote	15,967	Delta	13,679
3	Beryl	16,943	Ely	14,347
4	Beryl	16,943	Coyote	12,195
5	Milford	17,221	Ely	14,347
6	Milford	17,221	Coyote	12,195

T3987/9-5-81/F

Results

Tables C-4 through C-11 show for each alternative (including the Proposed Action, which is labeled Alternative 0) the OB pairs and their populations, the resource locations, appeal indexes, the distances from the resources to each of the basing sites, the individual effect indexes and the combined effect index. In Table 3, for example, Snake Valley has an appeal rating of 3, ranges from 132 to 225 mi (and a mean distance of 178.5 mi) from Base A; Coyote Spring is given an effect index ranging from 7,245 to 1,607. Snake Valley is much closer to Base B, Milford, (43 to 112 mi) giving effect indexes ranging from greater than 12,020 to 7,400. The combined effect indexes of the two bases range from 19,300 to 9,000. Table C-11 is produced by combining the last column (Average Combined Effects) from each of the preceding seven tables. The data in Table C-11 were then sorted for combined effects indexes greater than 10,000 and ranked in order of that effect index (Table 11).

Conclusions and Disclaimers

This analysis considers only indirect potential impact of OB sites on resources--and only the operational stage. Short-term impacts are not evaluated. Nor are already existing impacts considered, but only those impacts which would be added to the region as a result of the base construction and occupation. This may not be reasonable in the case of Clark County where the additional impact of 20,000 people may be negligible for many resources. In this case, the analysis may overemphasize the impact of an OB site in or near an already populous region.

The split basing alternative (Alternative 8) was not analyzed because in an ordinal ranking system, Alternative 8 would be the alternative with least impact, since only one base would be located in the region rather than two bases.

Table C-4. EFFECT INDEX OF BASING ALTERNATIVES ON GREAT BASIN VALLEYS

ALTERNATIVE NO 0
BASE A COYOTE LONG TERM POP 15967.0
BASE B MILFORD LONG TERM POP 13071.0

LOCATION			MILES TO A			EFFECT INDEX OF BASE A			MILES TO B			EFFECT INDEX OF BASE B			COMBINED EFFECTS		
NO	APPL	NAME	N	F	AVE	MAX	MIN	AVE	N	F	AVE	MAX	MIN	AVE	MAX	MIN	AVE
4	3.0	SNAKE	132.0	223.0	178.5	7245.1	1607.4	3764.2	43.0	112.0	77.5	12019.6	7400.2	9954.3	19264.7	9007.6	13718.4
5	1.0	PINE	108.0	152.0	130.0	136.7	1.3	16.1	25.0	51.0	38.0	10127.9	4521.1	7250.0	10264.6	4522.4	7266.2
6	2.0	WHITE	158.0	214.0	186.0	1250.0	149.2	467.9	40.0	103.0	71.5	11102.1	4427.5	7758.1	12352.1	4576.7	8225.9
7	1.0	FISH SPR	198.0	245.0	221.5	0.0	0.0	0.0	82.0	129.0	105.5	840.2	14.7	139.1	840.2	14.7	139.1
8	1.0	DUGWAY	220.0	252.0	236.0	0.0	0.0	0.0	98.0	132.0	115.0	259.3	10.7	59.2	259.3	10.7	59.2
9	2.0	GOVT CRK	231.0	263.0	247.0	68.9	13.7	31.6	103.0	143.0	123.0	4427.5	1622.2	2791.6	4496.5	1635.9	2823.2
46	3.0	SEV DES	171.0	263.0	217.0	4239.3	693.2	1687.0	35.0	129.0	82.0	12364.6	6145.4	9635.5	16604.0	6838.6	11322.4
46A	1.0	SEV LAKE	154.0	195.0	174.5	1.0	0.0	0.1	23.0	77.0	50.0	10532.6	1162.3	4711.4	10533.6	1162.3	4711.5
50	1.0	MILFORD	117.0	159.0	138.0	59.8	0.5	6.7	0.0	20.0	10.0	13071.0	11102.1	12548.2	13130.8	11102.6	12555.0
53	3.0	BERYL-ENT	77.0	119.0	98.0	12202.4	8400.6	10329.1	23.0	80.0	51.5	12761.1	9778.1	11589.7	24963.6	18178.7	21918.8
54	1.0	WAH WAH	123.0	163.0	143.0	33.2	0.0	3.8	9.0	49.0	29.0	12645.9	4905.7	9273.2	12679.1	4906.0	9277.0
137A	2.0	BIG SMOKY	149.0	194.0	171.5	1657.2	343.0	794.0	211.0	258.0	234.5	139.1	14.7	47.8	1796.3	357.7	841.8
139	1.0	KOBEH	189.0	226.0	207.5	0.0	0.0	0.0	178.0	215.0	196.5	0.0	0.0	0.0	0.0	0.0	0.0
140	2.0	MONITOR	151.0	203.0	177.0	1558.8	238.2	652.9	186.0	209.0	197.5	383.0	151.5	244.2	1941.7	389.6	897.1
142	1.0	ALKALI SPR	134.0	157.0	145.5	10.5	0.7	2.8	218.0	235.0	226.5	0.0	0.0	0.0	10.5	0.7	2.8
149	1.0	STONE CBN	112.0	155.0	133.5	95.4	0.9	11.1	177.0	206.0	191.5	0.0	0.0	0.0	95.5	0.9	11.1
151	1.0	ANTELOPE	169.0	197.0	183.0	0.1	0.0	0.0	172.0	194.0	183.0	0.1	0.0	0.0	0.2	0.0	0.0
154	1.0	NEWARK	166.0	217.0	191.5	0.2	0.0	0.0	142.0	180.0	161.0	0.5	0.0	0.0	0.7	0.0	0.0
155	1.0	LITTLE SMO	118.0	188.0	153.0	54.3	0.0	1.1	148.0	175.0	161.5	1.7	0.0	0.0	56.0	0.1	1.4
156	2.0	HOT CRK	105.0	163.0	134.0	5183.7	1061.2	2555.5	160.0	186.0	173.0	959.0	383.0	616.6	6142.7	1444.2	3172.1
170	2.0	PENOYER	65.0	95.0	80.0	10375.0	6357.3	8310.0	134.0	168.0	151.0	2092.1	733.7	1276.0	12467.1	7091.0	9586.1
171	1.0	COAL	62.0	97.0	79.5	3325.2	343.0	1210.3	106.0	134.0	120.0	133.2	8.6	36.6	3458.5	351.6	1246.9
172	2.0	GARDEN	69.0	109.0	89.0	9822.8	4750.2	7115.4	117.0	142.0	129.5	3233.5	1670.0	2351.1	13056.3	6420.2	9476.5
173	1.0	RAILROAD	83.0	171.0	127.0	959.5	0.1	22.1	118.0	178.0	148.0	44.5	0.0	1.7	1004.0	0.1	23.8
174	1.0	JAKES	155.0	186.0	170.5	0.9	0.0	0.1	123.0	145.0	134.0	27.2	2.5	8.6	28.1	2.5	8.7
175	1.0	LONG	178.0	232.0	205.0	0.0	0.0	0.0	142.0	171.0	156.5	0.5	0.1	0.6	0.5	0.1	0.6
178	1.0	BUTTE	178.0	254.0	216.0	0.0	0.0	0.0	129.0	185.0	157.0	14.7	0.0	0.6	14.7	0.0	0.6
179	2.0	STEPTOE	132.0	243.0	187.5	2598.1	38.6	441.8	92.0	171.0	131.5	5510.9	661.4	2238.7	8209.0	700.0	2680.1
180	2.0	CAVE	97.0	138.0	117.5	6113.0	2287.0	3902.9	86.0	103.0	94.5	6145.4	4427.5	5254.8	12258.4	6714.6	9157.7
181	1.0	DRY LAKE	49.0	112.0	80.5	5992.6	95.4	1133.7	80.0	108.0	94.0	959.0	111.9	354.8	6951.6	207.3	1488.5
182	1.0	DELAMAR	29.0	58.0	43.5	11327.8	4044.9	7375.6	100.0	120.0	110.0	220.6	36.6	93.6	11548.4	4081.5	7469.2
183	2.0	LAKE	100.0	138.0	119.0	5755.3	2297.0	3764.2	63.0	92.0	77.5	8718.1	5510.9	7081.7	14473.3	7797.9	10845.9
184	2.0	SPRING	112.0	218.0	165.0	4439.4	125.1	992.5	62.0	142.0	102.0	8830.0	1670.0	4521.1	13269.4	1795.1	5513.6
196	2.0	HAMLIN	91.0	145.0	118.0	5858.7	1868.5	3856.3	37.0	75.0	56.0	11366.9	7362.6	9491.5	18225.6	9231.1	13347.8
202	2.0	PATTERSON	75.0	103.0	89.0	8993.9	5408.5	7115.4	62.0	85.0	73.5	8830.0	6253.6	7531.9	17823.8	11662.1	14647.2
207	2.0	WHITERIVER	89.0	169.0	129.0	7115.4	966.0	2922.6	97.0	135.0	116.0	5004.3	2035.4	3311.3	12119.7	2901.4	6233.8
208	1.0	PAHROC	22.0	66.0	44.0	13104.7	2698.1	7245.1	108.0	138.0	123.0	111.9	5.5	27.2	13216.6	2703.6	7272.3
209	1.0	PAHRANAGAT	22.0	66.0	44.0	13104.7	2698.1	7245.1	108.0	138.0	123.0	111.9	5.5	27.2	13216.6	2703.6	7272.3
210	1.0	COYOTE	0.0	31.0	15.5	15967.0	10786.3	14475.6	123.0	180.0	151.5	27.2	0.0	1.1	15994.2	10786.3	14476.7
141	1.0	RALSTON	123.0	168.0	145.5	33.2	0.2	2.8	194.0	222.0	208.0	0.0	0.0	0.0	33.2	0.2	2.8
3	2.0	DEEP CRK	209.6	244.0	226.8	180.4	36.7	93.9	117.6	149.6	133.6	3187.4	1332.0	2115.0	3367.8	1368.7	2198.9
47	2.0	HUNTINGTON	224.0	272.0	248.0	95.4	8.4	30.0	181.6	220.0	200.8	451.7	93.6	213.5	547.1	102.0	243.6
48	3.0	BEAVER	149.6	180.0	164.8	5786.6	3673.5	4659.1	17.6	48.0	32.8	12088.7	11774.1	12448.6	18675.3	15447.6	17107.7
49	2.0	PAROWAN	129.6	168.0	148.8	2876.7	896.3	1667.3	24.0	44.0	34.0	12324.9	10727.9	11516.6	15201.5	11624.2	13233.9
51	1.0	CEDAR CITY	105.6	149.6	127.6	168.5	1.7	20.8	16.0	49.6	32.8	11774.1	4788.7	8425.6	11942.6	4790.4	8446.4
52	1.0	LUND DIST	104.0	140.0	122.0	193.2	5.4	36.7	12.0	48.0	30.0	12324.9	5103.8	9052.6	12518.1	5109.2	9089.3
53	1.0	PINE(N)	224.0	277.6	250.8	0.0	0.0	0.0	200.0	236.0	218.0	0.0	0.0	0.0	0.0	0.0	0.0
54	1.0	CRESENT	249.6	280.0	264.8	0.0	0.0	0.0	228.0	236.0	232.0	0.0	0.0	0.0	0.0	0.0	0.0
55	1.0	CARICO L	236.0	272.0	254.0	0.0	0.0	0.0	233.6	253.6	243.6	0.0	0.0	0.0	0.0	0.0	0.0
56	3.0	UPPER REES	193.6	256.0	224.8	348.5	19.9	92.0	232.0	253.6	242.8	53.8	18.5	31.9	402.4	38.4	123.9
137B	2.0	BIG SMOKY	176.0	232.0	204.0	676.9	65.8	228.5	212.0	237.6	224.8	133.2	41.2	75.3	810.1	106.9	303.9
138	1.0	GRASS	220.0	253.6	236.8	0.0	0.0	0.0	217.6	240.0	228.8	0.0	0.0	0.0	0.0	0.0	0.0
150	1.0	LIT FISH L	153.6	181.6	167.6	1.0	0.0	0.2	180.0	196.0	188.0	0.0	0.0	0.0	1.1	0.0	0.2
153	1.0	DIAMOND	196.0	248.0	222.0	0.0	0.0	0.0	173.6	212.0	192.8	0.1	0.0	0.0	0.1	0.0	0.0
161	1.0	INDIAN SPR	37.6	65.6	51.6	8966.4	2756.7	5385.8	160.0	204.0	182.0	0.4	0.0	0.0	8966.7	2756.7	5385.8
169	1.0	TIKABOO S	8.0	41.6	24.8	15555.3	7878.8	12422.2	137.6	157.6	147.6	5.8	0.5	1.8	15561.1	7879.3	12424.0
76	3.0	RUBY	224.0	288.0	256.0	1640.4	371.2	817.4	176.0	216.0	196.0	3207.8	1575.4	2289.1	4848.3	1946.5	3106.5
85	1.0	TIPPETT	204.0	232.0	218.0	0.0	0.0	0.0	120.0	144.0	132.0	36.6	2.8	10.7	36.6	2.8	10.7
95	1.0	ANTELOPE	233.6	261.6	247.6	0.0	0.0	0.0	141.6	172.0	156.8	3.6	0.1	0.6	3.6	0.1	0.6
87	1.0	GOSHUTE	241.6	288.0	264.8	0.0	0.0	0.0	161.6	204.0	182.8	0.0	0.0	0.0	0.0	0.0	0.0
198	2.0	DRY	80.0	96.0	88.0	8310.0	6234.6	7245.1	56.0	73.6	64.8	9491.5	7520.6	8515.8	17801.5	13755.2	15760.9
201	3.0	SPRING	96.0	116.0	106.0	10512.5	9673.5	9992.2	52.0	68.0	60.0	11562.5	10598.3	11102.1	22075.0	19271.8	20694.3
205	2.0	MEADOW V	8.0	64.0	36.0	15863.1	10512.5	13989.1	88.0	140.0	114.0	5931.0	1769.0	3470.4	21794.1	12281.5	17459.5
206	1.0	KANE SPR	16.0	48.0	32.0	14382.8	6234.6	10512.5	101.6	128.0	114.8	193.4	16.3	60.3	14576.2	6250.9	10572.8
211	1.0	THREE LAK	20.0	60.0	40.0	13561.8	3673.5	8310.0	160.0	197.6	178.8	0.4	0.0	0.0	13562.2	3673.5	8310.1
215	3.0	BLACK MTNS	36.0	60.0	48.0	15055.6	13561.8	14382.8	141.6	180.0	160.8	5265.0	3007.2	4046.1	20320.5	16569.0	18428.9
216	2.0	GARNET	16.0	36.0	26.0	15555.3	13989.1	14902.7	152.0	169.6	160.8	1237.2	594.4	934.2	16792.5	14603.5	15837.0
217	2.0	HIDDEN V N	16.0	28.0	22.0	15555.3	14739.4	15197.6	152.0	164.0	158.0	1237.2	840.2	1023.0	16792.5	15579.6	16220.9
218	2.0	CALIF WASH	13.6	40.0	26.8	15668.5	13561.8	14838.6	140.0	165.6	152.8	1769.0	796.2	1206.8	17437.4	14358.0	16045.4
219	1.0	MUDDY R	8.0	16.0	12.0	15555.3	14382.8	15055.6	136.0	149.6	142.8	6.9	1.4	3.2	15562.2	14384.2	15058.8
220	1.0	LOWER MO	20.0	37.6	28.8	13561.8	8966.4	11381.4	121.6	152.0	136.8	31.0	1.0	6.3	13593.1	8967.4	11387.7
221	1.0	TULE DES	33.6	56.0	44.8	10071.6	4439.4	7038.0	88.0	112.0	100.0	554.1	78.1	220.6	10625.7	4517.5	7258.6
222	2.0	VIRGIN R	28.0	76.0	52.0	14739.4	8856.4	12117.0	68.0	141.6	104.8	8154.4	1689.5	4261.7	22893.8	10545.9	16378.7
223	3.0	GOLD BUTTE	40.0	68.0	54.0	14849.4	12946.4	13989.1	128.0	164.0	146.0	6217.4	3859.8	4971.3	21066.9	16806.2	18960.4

Table C-5. EFFECT INDEX OF BASING ALTERNATIVES ON GREAT BASIN VALLEYS

ALTERNATIVE NO 1
BASE A COYOTE LONG TERM POP 15967.0
BASE B BERYL LONG TERM POP 12834.0

LOCATION NO	LOCATION APPL	LOCATION NAME	MILES TO A N	MILES TO A F	MILES TO A AVE	EFFECT INDEX OF BASE A MAX	EFFECT INDEX OF BASE A MIN	EFFECT INDEX OF BASE A AVE	MILES TO B N	MILES TO B F	MILES TO B AVE	EFFECT INDEX OF BASE B MAX	EFFECT INDEX OF BASE B MIN	EFFECT INDEX OF BASE B AVE	COMBINED EFFECTS MAX	COMBINED EFFECTS MIN	COMBINED EFFECTS AVE
4	3.0	SNAKE	132.0	225.0	178.5	7249.1	1607.4	3764.2	51.0	137.0	94.0	11406.0	5478.9	8596.6	18655.1	7086.2	12360.8
5	1.0	PINE	108.0	152.0	130.0	136.7	1.0	16.1	18.0	62.0	40.0	11244.2	2672.8	6679.5	11380.9	2673.8	6695.6
6	2.0	WHITE	158.0	214.0	186.0	1250.0	149.2	467.8	68.0	126.0	97.0	8006.6	2539.8	4913.5	9256.6	2689.0	5381.4
7	1.0	FISH SPR	198.0	245.0	221.5	0.0	0.0	0.0	108.0	154.0	131.0	109.8	0.8	11.7	109.8	0.8	11.7
8	1.0	DUGWAY	220.0	252.0	236.0	0.0	0.0	0.0	126.0	162.0	144.0	19.7	0.3	2.7	19.7	0.3	2.7
9	2.0	GOVT CRK	231.0	263.0	247.0	68.9	13.7	31.6	135.0	174.0	154.5	1998.5	584.0	1123.4	2067.5	598.1	1155.0
46	3.0	SEV DES	171.0	263.0	217.0	4239.0	693.2	1887.0	72.0	166.0	119.0	10145.2	3678.1	6752.2	14384.5	4371.3	8639.2
46A	1.0	SEV LAKE	154.0	195.0	174.5	1.0	0.0	0.1	54.0	105.0	79.5	3903.6	142.6	972.8	3904.6	142.6	972.9
50	1.0	MILFORD	117.0	159.0	138.0	59.8	0.5	6.7	28.0	71.0	49.5	9319.4	1639.9	4720.9	9379.2	1640.3	4727.6
53	3.0	BERYL-ENT	77.0	119.0	98.0	12202.4	8400.6	10329.1	0.0	20.0	10.0	12834.0	12603.0	12775.9	25036.4	21003.9	23105.1
54	1.0	WAH WAH	123.0	163.0	143.0	33.2	0.0	3.8	26.0	71.0	48.5	9739.4	1639.8	4913.5	9772.6	1640.1	4917.3
107A	2.0	BIG SMOKY	149.0	194.0	171.5	1657.2	343.0	794.0	192.0	229.0	210.5	298.0	60.9	139.5	1955.5	403.9	933.5
139	1.0	KOBEH	189.0	226.0	207.5	0.0	0.0	0.0	169.0	212.0	190.5	0.1	0.0	0.0	0.1	0.0	0.0
140	2.0	MONITOR	151.0	203.0	177.0	1558.8	238.2	652.9	156.0	195.0	180.5	771.0	265.0	461.9	2330.0	503.2	1114.6
142	1.0	ALKALI SPR	134.0	157.0	145.5	10.5	0.7	2.8	188.0	206.0	197.0	0.0	0.0	0.0	10.5	0.7	2.8
149	1.0	STONE CBN	112.0	155.0	133.5	95.4	0.9	11.1	149.0	174.0	161.5	1.5	0.1	0.3	96.9	0.9	11.4
151	1.0	ANTELOPE	169.0	197.0	183.0	0.1	0.0	0.0	158.0	182.0	170.0	0.5	0.0	0.1	0.6	0.0	0.1
154	1.0	NEWARK	166.0	217.0	191.5	0.2	0.0	0.0	134.0	178.0	156.0	8.4	0.0	0.6	8.6	0.0	0.6
155	1.0	LITTLE SMO	118.0	188.0	153.0	54.3	0.0	1.1	135.0	165.0	150.0	7.5	0.2	1.3	61.9	0.2	2.4
156	2.0	HOT CRK	105.0	163.0	134.0	5183.7	1061.2	2555.6	137.0	157.0	147.0	1890.6	1037.6	1415.0	7074.3	2098.8	3970.5
170	2.0	PENOYER	65.0	95.0	80.0	10375.0	6357.0	8310.0	102.0	132.0	117.0	4439.2	2168.7	3174.9	14814.2	8526.0	11484.9
171	1.0	COAL	62.0	97.0	79.5	3325.2	343.0	1210.0	75.0	100.0	87.5	1292.0	216.6	563.9	4617.2	559.7	1774.1
172	2.0	GARDEN	69.0	109.0	89.0	9822.8	4750.2	7115.4	89.0	112.0	100.5	5719.2	3568.0	4578.9	15542.0	8318.5	11694.3
173	1.0	RAILROAD	93.0	171.0	127.0	959.5	0.1	22.1	98.0	149.0	123.5	254.6	1.5	25.4	1214.2	1.6	47.5
174	1.0	LAKES	155.0	186.0	170.5	0.9	0.0	0.1	118.0	142.0	130.0	43.7	3.4	13.0	44.5	3.4	13.1
175	1.0	LONG	178.0	232.0	205.0	0.0	0.0	0.0	138.0	169.0	153.5	5.4	0.1	0.9	5.4	0.1	0.9
178	1.0	BUTTE	178.0	254.0	216.0	0.0	0.0	0.0	129.0	194.0	161.5	14.4	0.0	0.3	14.4	0.0	0.3
179	2.0	STEPTOE	132.0	243.0	187.5	2698.1	38.6	441.8	129.0	182.0	155.5	2349.1	437.0	1088.4	5047.3	475.6	1530.2
180	2.0	CAVE	97.0	138.0	117.5	6113.0	2287.0	3902.9	71.0	92.0	81.5	7673.0	5410.9	6516.4	13786.0	7698.0	10419.3
181	1.0	DRY LAKE	49.0	112.0	80.5	5992.6	95.4	1133.7	49.0	69.0	59.0	4816.7	1838.3	3099.6	10809.3	1933.7	4233.3
182	1.0	DELAMAR	29.0	58.0	43.5	11327.8	4044.9	7375.6	63.0	83.0	73.0	2539.8	771.3	1457.9	13867.6	4816.2	8833.5
183	2.0	LAKE	100.0	138.0	119.0	5755.3	2287.0	3764.2	45.0	83.0	64.0	10438.1	6354.3	9449.8	16193.4	8641.4	13213.9
184	2.0	SPRING	112.0	218.0	165.0	4439.4	125.1	992.7	49.0	151.0	100.0	10045.2	1252.9	4626.0	14484.7	1378.0	5618.5
185	2.0	HAMLIN	91.0	145.0	118.0	6858.7	1868.5	3856.0	11.0	75.0	43.0	12676.5	7229.1	10627.0	19535.3	9097.6	14483.0
202	2.0	PATTERSON	75.0	103.0	89.0	8993.9	5408.5	7115.4	35.0	60.0	47.5	11326.0	8888.4	10194.7	20319.8	14296.9	17310.1
207	2.0	WHITERIVER	89.0	169.0	129.0	7115.4	866.0	2922.6	74.0	123.0	98.5	7339.9	2741.0	4768.7	14455.3	3607.0	7691.3
208	1.0	PAHROC	22.0	66.0	44.0	13104.7	2698.1	7245.1	74.0	100.0	87.0	1373.0	216.6	584.3	14477.7	2914.8	7829.4
209	1.0	PAHRANAGAT	22.0	66.0	44.0	13104.7	2698.1	7245.1	74.0	100.0	87.0	1373.0	216.6	584.3	14477.7	2914.8	7829.4
210	1.0	COYOTE	0.0	31.0	15.5	15967.0	10786.3	14475.6	71.0	114.0	92.5	1639.8	63.8	390.5	17606.8	10850.1	14866.1
141	1.0	RALSTON	123.0	168.0	145.5	33.2	0.2	2.9	171.0	194.0	182.5	0.1	0.0	0.0	33.3	0.2	2.9
3	2.0	DEEP CRK	209.6	244.0	226.8	180.4	36.7	93.9	132.0	164.0	148.0	2168.7	825.0	1373.0	2349.2	861.7	1466.9
47	2.0	HUNTINGTON	224.0	272.0	248.0	95.4	8.4	30.0	181.6	224.0	202.8	443.5	76.7	193.1	538.9	85.1	223.1
48	3.0	BEAVER	149.6	180.0	164.8	5786.6	3673.5	4659.1	52.0	81.6	66.8	11352.8	9488.9	10462.7	17139.5	13162.4	15121.8
49	2.0	PAROWAN	129.6	168.0	148.8	2876.7	396.3	1667.0	41.6	72.0	56.8	10756.5	7561.9	9234.0	13633.2	7958.2	10901.0
51	1.0	CEDAR CITY	105.6	149.6	127.6	168.5	1.7	20.8	28.0	52.0	40.0	9319.4	4256.4	6679.5	9487.9	4258.1	6700.3
52	1.0	LUND DIST	104.0	140.0	122.0	193.2	5.4	36.7	8.0	40.0	24.0	12503.1	6679.5	10145.2	12696.3	6684.8	10181.9
53	1.0	PINE(N)	224.0	277.6	250.8	0.0	0.0	0.0	196.0	237.6	216.8	0.0	0.0	0.0	0.0	0.0	0.0
54	1.0	CRESENT	249.6	280.0	264.8	0.0	0.0	0.0	224.0	248.0	236.0	0.0	0.0	0.0	0.0	0.0	0.0
55	1.0	CARICO L	236.0	272.0	254.0	0.0	0.0	0.0	224.0	248.0	236.0	0.0	0.0	0.0	0.0	0.0	0.0
56	2.0	UPPER REES	193.6	256.0	224.8	348.5	19.9	92.0	212.0	244.0	228.0	130.8	29.5	63.8	479.3	49.4	155.8
137B	2.0	BIG SMOKY	176.0	232.0	204.0	676.9	65.8	228.5	192.0	221.6	206.8	298.3	85.5	163.4	975.2	151.3	391.9
138	1.0	GRASS	220.0	253.6	236.8	0.0	0.0	0.0	208.0	232.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0
150	1.0	LIT FISH L	153.6	181.6	167.6	1.0	0.0	0.2	160.0	176.0	168.0	0.4	0.0	0.1	1.4	0.1	0.3
153	1.0	DIAMOND	196.0	248.0	222.0	0.0	0.0	0.0	168.0	208.0	188.0	0.1	0.0	0.0	0.1	0.0	0.0
161	1.0	INDIAN SPR	37.6	65.6	51.6	8966.4	2756.7	5385.8	124.0	165.6	144.8	24.1	0.2	2.5	8990.5	2756.9	5388.3
169	1.0	TIKABOO S	8.0	41.6	24.8	15555.0	7878.8	12422.2	100.0	120.0	110.0	216.6	36.0	91.9	15771.9	7914.7	12514.2
176	3.0	RUBY	224.0	288.0	256.0	1640.4	371.2	917.4	176.0	228.0	202.0	3149.6	1214.8	2016.9	4790.1	1585.9	2934.3
185	1.0	TIPPETT	204.0	232.0	218.0	0.0	0.0	0.0	132.0	157.6	144.8	10.5	0.5	2.5	10.5	0.5	2.5
186	1.0	ANTELOPE	233.6	261.6	247.6	0.0	0.0	0.0	152.0	188.0	170.0	1.0	0.0	0.1	1.0	0.0	0.1
187	1.0	GOSHUTE	241.6	288.0	264.8	0.0	0.0	0.0	173.6	208.0	190.8	0.1	0.0	0.0	0.1	0.0	0.0
199	2.0	DRY	32.0	96.0	59.0	8310.0	6234.6	7245.1	24.0	40.0	32.0	12101.4	10900.8	11560.7	20411.4	17135.4	18805.8
201	3.0	SPRING	96.0	116.0	106.0	10512.5	8673.5	9592.2	24.0	52.0	38.0	12503.1	11352.8	12020.5	23015.6	20026.4	21612.7
205	2.0	MEADOW V	8.0	64.0	36.0	15863.1	10512.5	13989.1	49.6	104.0	76.8	9984.8	4256.4	7030.4	25847.8	14768.9	21019.5
206	1.0	KANE SPR	16.0	48.0	32.0	14382.8	6234.6	10512.5	64.0	92.0	78.0	2411.5	405.5	1071.3	16794.3	6640.1	11583.8
211	1.0	THREE LAK	20.0	60.0	40.0	13561.8	8673.5	9313.0	121.6	160.0	140.8	30.7	0.4	3.9	13592.5	8673.8	9316.9
213	3.0	BLACK MTNS	36.0	60.0	48.0	15055.6	13561.8	14382.8	108.0	144.0	126.0	7561.9	5011.3	6247.0	22617.4	18573.1	20629.8
216	2.0	GARNET	16.0	36.0	26.0	15555.3	13989.1	14902.7	116.0	133.6	124.8	3251.2	2076.7	2619.0	18806.5	16065.8	17521.8
217	2.0	HIDDEN V N	16.0	28.0	22.0	15555.3	14739.4	15197.6	113.6	129.0	120.8	3439.3	2411.5	2895.2	18994.6	17150.9	18092.8
218	2.0	CALIF WASH	12.6	40.0	26.3	15668.5	13561.8	14839.6	104.0	132.0	118.0	4256.4	2168.7	3099.6	19924.9	15730.5	17939.2
219	1.0	MUDDY R	8.0	16.0	12.0	15555.3	14382.8	15055.6	17.6	112.0	64.8	11309.8	76.7	2312.2	26865.1	14459.5	17367.8
220	1.0	LOWER MO	20.0	37.6	28.8	12561.8	8966.4	11381.4	84.0	116.0	100.0	720.4	52.9	216.6	14282.3	9019.2	11598.0
221	1.0	TULE DES	33.6	56.0	44.8	10071.6	4439.4	7038.0	49.6	76.0	62.8	4701.8	1214.8	2566.0	14773.5	5654.2	9604.0
222	2.0	VIRGIN R	28.0	76.0	52.0	14739.4	9836.4	12117.0	32.0	108.0	70.0	11560.7	3903.6	7784.2	26300.1	13739.9	19901.2
223	3.0	GOLD BUTTE	40.0	68.0	54.0	14849.4	12946.4	13989.1	96.0	132.0	114.0	8449.8	5823.5	7118.6	23299.[illegible]	18769.9	21107.7

Table C-6.

EFFECT INDEX OF BASING ALTERNATIVES ON GREAT BASIN VALLEYS

ALTERNATIVE NO 2
BASE A COYOTE LONG TERM POP 15967.0
BASE B DELTA LONG TERM POP 13679.0

LOCATION			MILES TO A			EFFECT INDEX OF BASE A			MILES TO B			EFFECT INDEX OF BASE B			COMBINED EFFECTS		
NO	APPL	NAME	N	F	AVE	MAX	MIN	AVE	N	F	AVE	MAX	MIN	AVE	MAX	MIN	AVE
4	3.0	SNAKE	132.0	225.0	178.5	7245.1	1607.4	3764.2	35.0	77.0	56.0	12939.8	10453.9	11865.6	20184.8	12061.3	15629.7
5	1.0	PINE	108.0	152.0	130.0	136.7	1.3	16.1	48.0	91.0	69.5	5341.2	465.7	1904.7	5477.9	467.0	1920.8
6	2.0	WHITE	158.0	214.0	186.0	1250.0	149.2	467.8	22.0	48.0	35.0	13019.8	10813.1	12071.7	14269.9	10962.3	12539.5
7	1.0	FISH SPR	198.0	245.0	221.5	0.0	0.0	0.0	22.0	63.0	42.5	11226.9	2707.1	6544.4	11226.9	2707.1	6544.4
8	1.0	DUGWAY	220.0	252.0	236.0	0.0	0.0	0.0	32.0	66.0	49.0	9006.1	2311.5	5133.9	9006.1	2311.5	5133.9
9	2.0	GOVT CRK	231.0	263.0	247.0	68.9	12.7	31.6	35.0	77.0	56.0	12071.7	7469.8	9933.0	12140.6	7483.5	9964.6
46	3.0	SEV DES	171.0	263.0	217.0	4239.3	693.2	1887.0	0.0	66.0	33.0	13679.0	11226.9	13019.8	17918.3	11920.1	14906.8
46A	1.0	SEV LAKE	154.0	195.0	174.5	1.0	0.0	0.1	2.0	48.0	25.0	13656.7	5341.2	10599.0	13657.7	5341.2	10599.1
50	1.0	MILFORD	117.0	159.0	138.0	59.8	0.5	6.7	35.0	129.0	82.0	2296.7	15.4	879.3	2356.5	15.9	886.0
53	3.0	BERYL-ENT	77.0	119.0	98.0	12202.4	8400.6	10329.1	72.0	166.0	119.0	10813.1	3920.3	7196.8	22015.5	12320.8	17526.0
54	1.0	WAH WAH	123.0	163.0	143.0	33.2	0.3	3.8	35.0	74.0	54.5	8296.7	1463.4	4069.5	8330.0	1463.7	4073.3
137A	2.0	BIG SMOKY	149.0	194.0	171.5	1657.2	343.0	794.0	222.0	278.0	250.0	89.5	5.1	23.2	1746.7	348.2	817.2
139	1.0	KOBEH	189.0	226.0	207.5	0.0	0.0	0.0	168.0	205.0	186.5	0.1	0.0	0.0	0.1	0.0	0.0
140	2.0	MONITOR	151.0	203.0	177.0	1558.8	238.2	652.9	183.0	217.0	200.0	448.7	112.0	230.9	2007.5	350.3	883.8
142	1.0	ALKALI SPR	134.0	157.0	145.5	10.5	0.7	2.8	243.0	260.0	251.5	0.0	0.0	0.0	10.5	0.7	2.8
149	1.0	STONE CBN	112.0	155.0	133.5	95.4	0.9	11.1	194.0	232.0	213.0	0.0	0.0	0.0	95.4	0.9	11.1
151	1.0	ANTELOPE	169.0	197.0	183.0	0.1	0.0	0.0	163.0	186.0	174.5	0.3	0.0	0.1	0.4	0.0	0.1
154	1.0	NEWARK	166.0	217.0	191.5	0.2	0.0	0.0	131.0	155.0	143.0	12.4	0.8	3.2	12.6	0.8	3.2
155	1.0	LITTLE SMO	118.0	188.0	153.0	54.3	0.0	1.1	148.0	180.0	164.0	1.8	0.0	0.2	56.1	0.0	1.4
156	2.0	HOT CRK	105.0	163.0	134.0	5183.7	1061.2	2555.6	169.0	206.0	187.5	741.9	180.1	378.5	5925.6	1241.3	2934.1
170	2.0	PENOYER	65.0	95.0	80.0	10375.0	6357.3	8310.0	166.0	205.0	185.5	322.0	187.8	408.4	11197.1	6545.1	8718.5
171	1.0	COAL	62.0	97.0	79.5	3325.2	343.0	1210.3	140.0	172.0	156.0	4.5	0.1	0.7	3329.8	343.1	1210.9
172	2.0	GARDEN	69.0	109.0	89.0	9822.8	4750.2	7115.4	142.0	169.0	155.5	1747.7	741.9	1160.1	11570.5	5492.1	8275.5
173	1.0	RAILROAD	83.0	171.0	127.0	959.5	0.1	22.1	126.0	209.0	167.5	21.0	0.0	0.1	980.5	0.1	22.2
174	1.0	JAMES	155.0	186.0	170.5	0.9	0.0	0.1	111.0	132.0	121.5	89.5	11.2	33.1	90.4	11.2	33.2
175	1.0	LONG	178.0	232.0	205.0	0.0	0.0	0.0	120.0	143.0	131.5	38.3	3.2	11.8	38.4	3.2	11.8
178	1.0	BUTTE	178.0	254.0	216.0	0.0	0.0	0.0	106.0	138.0	122.0	139.4	5.8	31.5	139.5	5.9	31.5
179	2.0	STEPTOE	132.0	243.0	187.5	2698.1	38.6	441.8	86.0	126.0	106.0	6431.2	2707.1	4346.3	9129.4	2745.6	4788.1
180	2.0	CAVE	97.0	138.0	117.5	6113.0	2287.0	3902.9	100.0	123.0	111.5	4930.6	2921.5	3846.9	11043.6	5208.5	7749.8
181	1.0	DRY LAKE	49.0	112.0	80.5	5992.6	95.4	1133.7	105.0	151.0	128.0	152.0	1.2	17.1	6144.6	96.7	1150.8
182	1.0	DELAMAR	29.0	58.0	43.5	11327.8	4044.9	7375.6	151.0	174.0	162.5	1.2	0.1	0.0	11329.0	4045.0	7375.9
183	2.0	LAKE	100.0	138.0	119.0	5755.3	2287.0	3764.2	92.0	111.0	101.5	5767.2	3890.8	4780.9	11522.5	6177.8	8545.0
184	2.0	SPRING	112.0	218.0	165.0	4439.4	125.1	992.5	65.0	98.0	81.5	8888.3	5133.9	6945.4	13327.8	5259.0	7937.9
196	2.0	HAMLIN	91.0	145.0	118.0	6858.7	1868.5	3856.3	66.0	105.0	85.5	8770.3	4440.9	6487.8	15629.1	6309.4	10344.1
202	2.0	PATTERSON	75.0	103.0	89.0	8993.9	5408.5	7115.4	102.0	126.0	114.0	4731.4	2707.1	3631.8	13725.3	8115.6	10747.2
207	2.0	WHITERIVER	89.0	169.0	129.0	7115.4	866.0	2922.6	102.0	146.0	124.0	4731.4	1553.9	2848.8	11846.8	2419.9	5771.3
208	1.0	PAHROC	22.0	66.0	44.0	13104.7	2698.1	7245.1	151.0	189.0	170.0	1.2	0.0	0.1	13106.0	2698.2	7245.2
209	1.0	PAHRANAGAT	22.0	66.0	44.0	13104.7	2698.1	7245.1	151.0	189.0	170.0	1.2	0.0	0.1	13106.0	2698.2	7245.2
210	1.0	COYOTE	0.0	31.0	15.5	15967.0	10786.3	14475.6	171.0	263.0	217.0	0.1	0.0	0.0	15967.1	10786.3	14475.6
141	1.0	RALSTON	123.0	168.0	145.5	33.2	0.2	2.8	208.0	246.0	227.0	0.0	0.0	0.0	33.2	0.2	2.8
3	2.0	DEEP CRK	209.6	244.0	226.8	180.4	36.7	83.9	73.6	100.0	86.8	7870.4	4930.6	6341.2	8050.9	4967.3	6425.0
47	2.0	HUNTINGTON	224.0	272.0	248.0	95.4	5.4	30.0	160.0	189.6	174.8	1003.6	349.1	605.3	1099.0	357.5	635.4
48	3.0	BEAVER	149.6	180.0	164.8	5786.6	3673.5	4659.1	60.0	88.0	74.0	11618.5	9627.9	10670.9	17405.1	13301.3	15330.0
49	2.0	PAROWAN	129.6	168.0	148.8	2876.7	396.3	1667.3	81.6	116.0	98.8	6933.9	3465.3	5052.1	9810.5	4361.6	6719.3
51	1.0	CEDAR CITY	105.6	149.6	127.6	168.5	1.7	20.8	85.6	128.0	106.8	687.4	17.1	130.1	855.8	18.8	150.8
52	1.0	LUND DIST	104.0	140.0	122.0	193.2	5.4	36.7	84.0	128.0	106.0	767.9	17.1	139.4	961.0	22.4	176.1
53	1.0	PINE(N)	224.0	277.6	250.8	0.0	0.0	0.0	185.6	216.0	200.8	0.0	0.0	0.0	0.0	0.0	0.0
54	1.0	CRESENT	249.6	280.0	264.8	0.0	0.0	0.0	205.6	236.0	220.8	0.0	0.0	0.0	0.0	0.0	0.0
55	1.0	CARICO L	236.0	272.0	254.0	0.0	0.0	0.0	228.0	241.6	234.8	0.0	0.0	0.0	0.0	0.0	0.0
56	2.0	UPPER REES	193.6	256.0	224.8	348.5	19.9	92.0	232.0	265.6	248.8	56.3	10.2	24.7	404.9	30.1	116.7
137B	2.0	BIG SMOKY	176.0	232.0	204.0	676.9	65.8	228.5	217.6	256.0	236.8	109.1	17.1	44.8	785.9	82.8	273.3
138	1.0	GRASS	220.0	253.6	236.8	0.0	0.0	0.0	208.0	232.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0
150	1.0	LIT FISH L	153.6	181.6	167.6	1.0	0.0	0.2	193.6	216.0	204.8	0.0	0.0	0.0	1.1	0.0	0.2
153	1.0	DIAMOND	196.0	248.0	222.0	0.0	0.0	0.0	169.6	192.0	180.8	0.1	0.0	0.0	0.1	0.0	0.0
161	1.0	INDIAN SPR	37.6	65.6	51.6	8966.4	2756.7	5385.8	224.0	272.0	248.0	0.0	0.0	0.0	8966.4	2756.7	5385.8
169	1.0	TIKABOO S	8.0	41.6	24.8	15555.3	7878.8	12422.2	204.0	228.0	216.0	0.0	0.0	0.0	15555.3	7878.8	12422.2
176	3.0	RUBY	224.0	288.0	256.0	1640.4	371.2	817.4	145.6	169.6	157.6	5230.1	3711.2	4434.6	6870.6	4082.4	5252.0
185	1.0	TIPPETT	204.0	232.0	218.0	0.0	0.0	0.0	84.0	104.0	94.0	767.9	165.5	371.3	767.9	165.5	371.3
186	1.0	ANTELOPE	233.6	261.6	247.6	0.0	0.0	0.0	96.0	124.0	110.0	318.0	25.7	98.0	318.0	25.7	98.0
187	1.0	GOSHUTE	241.6	288.0	264.8	0.0	0.0	0.0	117.6	152.0	134.8	48.4	1.1	8.2	48.4	1.1	8.2
198	2.0	DRY	80.0	96.0	88.0	8310.0	6234.6	7245.1	120.0	136.0	128.0	3147.1	2072.0	2570.3	11457.1	8306.6	9815.4
201	3.0	SPRING	96.0	116.0	106.0	10512.5	8673.5	9592.2	105.6	121.6	113.6	8249.3	6995.5	7618.7	18761.8	15669.0	17210.9
205	2.0	MEADOW V	8.0	64.0	36.0	15863.1	10512.5	13989.1	156.0	213.6	184.8	1141.8	130.1	419.4	17004.9	10642.6	14408.5
206	1.0	KANE SPR	16.0	48.0	32.0	14382.8	6234.6	10512.5	172.0	200.0	186.0	0.1	0.0	0.0	14382.9	6234.6	10512.5
211	1.0	THREE LAK	20.0	60.0	40.0	13561.8	3673.5	8310.0	229.6	268.0	248.8	0.0	0.0	0.0	13561.8	3673.5	8310.0
215	3.0	BLACK MTNS	36.0	60.0	48.0	15055.6	13561.8	14382.8	220.0	256.0	238.0	1523.3	700.3	1048.1	16578.8	14262.1	15430.9
216	2.0	GARNET	16.0	36.0	26.0	15555.3	13989.1	14902.7	225.6	244.0	234.8	76.0	31.5	49.3	15631.3	14020.6	14952.0
217	2.0	HIDDEN V N	16.0	28.0	22.0	15555.3	14739.4	15197.6	225.6	237.6	231.6	76.0	43.1	57.4	15631.3	14782.5	15255.0
218	2.0	CALIF WASH	13.6	40.0	26.8	15668.5	13561.8	14838.6	213.6	241.6	227.6	130.1	35.4	69.3	15798.5	13597.2	14907.9
219	1.0	MUDDY R	8.0	16.0	12.0	15555.3	14382.8	15055.6	208.0	224.0	216.0	0.0	0.0	0.0	15555.3	14382.8	15055.6
220	1.0	LOWER MC	20.0	37.6	28.8	13561.8	8966.4	11381.4	196.0	228.0	212.0	0.0	0.0	0.0	13561.8	8966.4	11381.4
221	1.0	TULE DES	33.6	56.0	44.8	10071.6	4439.4	7038.0	161.6	185.6	173.6	0.3	0.0	0.1	10072.0	4439.4	7038.1
222	2.0	VIRGIN R	28.0	76.0	52.0	14739.4	3856.4	12117.0	140.0	220.0	180.0	1851.3	98.0	501.4	16590.7	3954.4	12618.4
223	3.0	GOLD BUTTE	40.0	68.0	54.0	14849.4	12946.4	13989.1	205.6	241.6	223.6	2011.3	969.2	1416.8	16860.9	13915.6	15405.9

Table C-7. EFFECT INDEX OF BASING ALTERNATIVES ON GREAT BASIN VALLEYS

ALTERNATIVE NO. 3
BASE A BERYL LONG TERM POP 16943.0
BASE B ELY LONG TERM POP 14347.0

LOCATION			MILES TO A			EFFECT INDEX OF BASE A			MILES TO B			EFFECT INDEX OF BASE B			COMBINED EFFECTS		
NO	APPL	NAME	N	F	AVE	MAX	MIN	AVE	N	F	AVE	MAX	MIN	AVE	MAX	MIN	AVE
4	3.0	SNAKE	51.0	137.0	94.0	15057.8	7233.0	11349.0	25.0	89.0	57.0	13946.0	10017.3	12381.4	29003.8	17250.3	23730.4
5	1.0	PINE	18.0	62.0	40.0	14844.2	3528.5	9818.0	58.0	94.0	76.0	3634.5	389.5	1358.0	18478.7	3918.0	13176.0
6	2.0	WHITE	68.0	126.0	97.0	10370.0	3353.0	6486.7	60.0	85.0	72.5	9936.3	6864.0	8391.2	20306.3	10217.0	14877.9
7	1.0	FISH SPR	108.0	154.0	131.0	145.0	1.1	15.4	85.0	108.0	96.5	751.7	122.8	320.7	896.7	123.8	336.0
8	1.0	DUGWAY	126.0	162.0	144.0	26.0	0.4	3.6	100.0	122.0	111.0	242.2	33.0	93.9	268.2	33.4	97.5
9	2.0	GOVT CRK	135.0	174.0	154.5	2638.4	771.4	1483.1	114.0	142.0	128.0	3809.2	1833.1	2695.8	6447.6	2604.5	4178.9
46	3.0	SEV DES	72.0	166.0	119.0	13393.3	4855.7	8914.1	82.0	155.0	118.5	10576.1	4825.8	7589.0	23969.4	9681.5	15503.1
46A	1.0	SEV LAKE	54.0	105.0	79.5	5153.4	188.2	1284.2	75.0	103.0	89.0	1444.3	188.9	565.3	6597.7	377.1	1850.0
50	1.0	MILFORD	28.0	71.0	49.5	12303.1	2164.7	6232.3	91.0	169.0	130.0	488.5	0.1	14.5	12791.6	2164.9	6246.8
53	3.0	BERYL-ENT	0.0	20.0	10.0	15743.0	16638.4	16866.3	83.0	180.0	131.5	10497.3	3300.8	6549.0	27440.3	19939.2	23415.3
54	1.0	WAH WAH	26.0	71.0	48.5	12837.6	2164.7	6486.7	69.0	100.0	84.5	2055.0	242.2	778.1	14912.6	2406.9	7264.8
137A	2.0	BIG SMOKY	192.0	229.0	210.5	393.9	80.4	184.2	123.0	183.0	153.0	3064.1	470.6	1316.4	3458.0	551.0	1500.6
139	1.0	KOBEH	169.0	212.0	190.5	0.1	0.0	0.0	72.0	109.0	90.5	1729.1	112.4	506.9	1729.3	112.4	506.9
140	2.0	MONITOR	166.0	195.0	180.5	1019.2	349.9	609.8	85.0	118.0	101.5	6864.0	3465.0	5014.3	7882.2	3814.9	5624.1
142	1.0	ALKALI SPR	188.0	206.0	197.0	0.0	0.0	0.0	149.0	168.0	158.5	1.7	0.1	0.5	1.7	0.1	0.5
149	1.0	STONE CBN	149.0	174.0	161.5	2.0	0.1	0.4	98.0	145.0	121.5	284.7	2.7	34.7	286.6	2.8	35.1
151	1.0	ANTELOPE	159.0	182.0	170.0	0.6	0.0	0.1	68.0	89.0	78.5	2173.2	565.8	1159.9	2173.8	565.9	1160.0
154	1.0	NEWARK	134.0	178.0	156.0	11.1	0.0	0.8	34.0	74.0	54.0	8950.5	1534.9	4363.5	8961.6	1534.9	4364.6
155	1.0	LITTLE SMO	135.0	165.0	150.0	10.0	0.3	1.7	49.0	88.0	68.5	5384.6	608.2	2113.5	5394.6	608.4	2115.2
156	2.0	HOT CRK	137.0	157.0	147.0	2495.9	1369.8	1868.0	71.0	120.0	95.5	8577.6	3300.8	5657.1	11073.5	4670.5	7525.0
170	2.0	HENOYER	102.0	132.0	117.0	5860.4	2863.1	4191.0	88.0	129.0	108.5	6510.0	2626.0	4315.8	12370.4	5489.1	8507.2
171	1.0	COAL	75.0	100.0	87.5	1705.6	286.0	744.4	56.0	105.0	85.5	2424.4	159.4	726.0	4130.0	445.4	1470.4
172	2.0	GARDEN	89.0	112.0	100.5	7550.3	4710.8	6044.9	53.0	102.0	82.5	9569.1	4962.5	7163.7	17119.4	9673.3	13208.6
173	1.0	RAILROAD	98.0	149.0	123.5	336.2	2.0	33.5	29.0	126.0	77.5	10178.5	22.0	1236.2	10514.6	24.3	1269.7
174	1.0	LAKES	118.0	142.0	130.0	37.6	4.5	17.1	15.0	37.0	26.0	13088.1	8205.2	10887.6	13145.8	8209.7	10904.7
175	1.0	LONG	138.0	169.0	153.5	7.1	0.1	1.1	34.0	75.0	54.5	8950.5	1444.3	4268.2	8957.6	1444.4	4269.3
178	1.0	BUTTE	129.0	194.0	161.5	19.0	0.0	0.4	23.0	97.0	60.0	11560.8	308.2	3300.8	11579.8	308.2	3301.2
179	2.0	STEPTOE	129.0	182.0	155.5	3101.2	576.9	1436.9	0.0	85.0	42.5	14347.0	6864.0	11932.1	17448.2	7440.9	13369.0
180	2.0	CAVE	71.0	92.0	81.5	10129.7	7143.3	8602.7	20.0	62.0	41.0	13773.2	9692.0	12085.5	23902.9	16835.3	20688.2
181	1.0	DRY LAKE	49.0	69.0	59.0	6358.9	2426.8	4092.0	46.0	109.0	77.5	6048.8	112.4	1236.2	12407.7	2539.2	5328.2
182	1.0	DELAMAR	63.0	83.0	73.0	3353.0	1018.2	1924.7	100.0	129.0	114.5	242.2	16.1	68.0	3595.2	1034.3	1992.7
183	2.0	LAKE	45.0	83.0	64.0	13780.1	8388.8	11155.1	25.0	68.0	46.5	13460.6	8950.5	11506.4	27240.6	17339.2	22661.5
184	2.0	SPRING	49.0	151.0	100.0	13261.4	1634.0	6107.1	9.0	64.0	36.5	14228.9	9445.9	12523.4	27490.3	11100.0	18630.4
196	2.0	HAMLIN	11.0	75.0	43.0	16735.1	9543.6	14029.8	34.0	95.0	64.5	12750.6	5712.3	9384.2	29485.7	15255.9	23413.9
202	2.0	PATTERSON	35.0	60.0	47.5	14952.1	11734.2	13458.7	58.0	91.0	74.5	10179.5	5152.9	8143.2	25130.6	17697.1	21601.9
207	2.0	WHITERIVER	74.0	123.0	98.5	9689.9	3618.6	6295.3	5.0	72.0	38.5	14310.4	8453.3	12333.2	24000.3	12071.9	18628.6
208	1.0	PAHROC	74.0	100.0	87.0	1812.6	286.0	771.4	97.0	138.0	117.5	308.2	6.0	51.2	2120.8	292.0	822.6
209	1.0	PAHRANAGAT	74.0	100.0	87.0	1912.6	286.0	771.4	97.0	138.0	117.5	308.2	6.0	51.2	2120.8	292.0	822.6
210	1.0	COYOTE	71.0	114.0	92.5	2164.7	84.2	515.6	132.0	243.0	187.5	11.7	0.0	0.0	2176.4	84.2	515.6
141	1.0	RALSTON	171.0	194.0	182.5	0.1	0.0	0.0	112.0	157.0	134.5	35.7	0.6	8.9	35.8	0.6	8.9
3	2.0	DEEP CRK	132.0	164.0	148.0	2863.1	1089.1	1812.6	60.0	89.6	74.8	9936.3	6323.9	8106.1	12799.4	7413.0	9918.7
47	2.0	HUNTINGTON	181.6	224.0	202.8	585.5	101.3	254.9	72.0	116.0	94.0	8453.3	3634.5	5823.5	9038.8	3735.8	6078.4
48	3.0	BEAVER	82.0	31.6	56.8	14987.6	12526.9	13838.9	125.6	152.0	138.8	7015.4	3031.6	5988.4	22003.0	17558.5	19827.3
49	2.0	PAROWAN	41.6	72.0	56.8	14200.4	9982.9	12190.4	136.0	156.0	146.0	2173.2	1197.5	1629.8	16373.5	11180.5	13820.1
51	1.0	CEDAR CITY	28.0	52.0	40.0	12303.1	5619.2	8818.0	128.0	156.0	142.0	17.9	0.7	3.8	12321.0	5619.9	8821.8
52	1.0	LUND DIST	8.0	40.0	24.0	16506.1	8818.0	13393.3	93.6	140.0	116.8	401.6	4.8	54.9	16907.7	8822.8	13448.0
53	1.0	PINE(N)	196.0	237.6	216.8	0.0	0.0	0.0	88.0	128.0	108.0	608.2	17.9	122.8	608.2	17.9	122.8
54	1.0	CRESENT	224.0	248.0	236.0	0.0	0.0	0.0	116.0	141.6	128.8	59.1	4.0	16.4	59.1	4.0	16.4
55	1.0	CARICO L	224.0	248.0	236.0	0.0	0.0	0.0	121.6	140.0	130.8	34.3	4.8	13.3	34.3	4.8	13.3
56	2.0	UPPER REES	212.0	244.0	228.0	172.7	39.0	84.2	125.6	152.0	138.8	2868.6	1358.0	2009.1	3041.2	1396.9	2093.3
137B	2.0	BIG SMOKY	192.0	221.6	206.8	393.9	112.9	215.7	108.0	141.6	124.8	4363.8	1854.4	2927.8	4757.6	1967.3	3143.5
138	1.0	GRASS	208.0	232.0	220.0	0.0	0.0	0.0	105.6	125.6	115.6	151.4	22.9	61.4	151.4	22.9	61.4
150	1.0	LIT FISH L	160.0	176.0	168.0	0.5	0.1	0.2	80.0	104.0	92.0	1052.6	173.6	453.3	1053.1	173.6	453.5
153	1.0	DIAMOND	168.0	208.0	188.0	0.2	0.0	0.0	61.6	97.6	79.6	3048.8	293.9	1080.4	3048.9	293.9	1080.4
161	1.0	INDIAN SPR	124.0	165.6	144.8	31.9	0.2	3.3	153.6	205.6	179.6	0.9	0.0	0.0	32.8	0.2	3.3
169	1.0	TIKABOO S	100.0	120.0	110.0	286.0	47.5	121.4	136.0	176.0	156.0	7.6	0.0	0.7	293.5	47.5	122.1
176	3.0	RUBY	176.0	228.0	202.0	4158.1	1603.7	2662.7	65.6	124.0	94.8	11803.3	7143.6	9544.5	15961.3	8747.3	12207.2
185	1.0	TIPPETT	132.0	157.6	144.8	13.8	0.7	3.3	45.6	73.6	59.6	6140.0	1572.3	3365.9	6153.8	1573.0	3369.1
186	1.0	ANTELOPE	152.0	188.0	170.0	1.4	0.0	0.1	68.0	100.0	84.0	2173.2	242.2	805.4	2174.5	242.2	805.5
187	1.0	GOSHUTE	173.6	208.0	190.8	0.1	0.0	0.0	77.6	128.0	102.8	1228.4	17.9	192.1	1228.4	17.9	192.1
198	2.0	DRY	24.0	40.0	32.0	15975.9	14390.8	15262.0	92.0	104.0	98.0	6048.8	4758.2	5384.6	22024.7	19149.0	20646.6
201	3.0	SPRING	24.0	52.0	38.0	16506.1	14987.6	15869.0	64.0	93.6	78.8	11914.8	9642.9	10825.8	28420.9	24630.5	26694.8
205	2.0	MEADOW V	49.6	104.0	76.8	13181.5	5619.2	9281.2	109.6	177.6	143.6	4211.5	574.1	1749.6	17393.0	6193.2	11030.8
206	1.0	KANE SPR	64.0	92.0	78.0	3195.6	535.3	1414.2	124.0	152.0	138.0	27.0	1.2	6.0	3210.6	536.5	1420.3
211	1.0	THREE LAK	121.6	160.0	140.8	40.5	0.5	5.2	173.6	205.6	189.6	0.1	0.0	0.0	40.6	0.5	5.2
215	3.0	BLACK MTNS	108.0	144.0	126.0	9982.9	6615.7	8247.0	189.6	209.6	199.6	2810.2	1956.5	2355.4	12793.1	8572.2	10602.5
216	2.0	GARNET	116.0	133.6	124.8	4292.2	2741.6	3457.6	181.6	201.6	191.6	495.8	226.8	338.8	4788.0	2968.4	3796.3
217	2.0	HIDDEN V N	113.6	128.0	120.8	4540.4	3183.6	3822.1	181.6	192.0	186.8	495.8	333.5	407.8	5036.2	3517.1	4229.9
218	2.0	CALIF WASH	104.0	132.0	118.0	5619.2	2863.1	4092.0	176.0	204.0	190.0	608.2	205.4	360.5	6227.3	3068.4	4452.6
219	1.0	MUDDY R	17.6	112.0	64.8	14930.7	101.3	3052.5	165.6	177.6	171.6	0.2	0.0	0.1	14930.9	101.3	3052.6
220	1.0	LOWER MO	84.0	116.0	100.0	931.1	69.8	286.0	165.6	193.6	179.6	0.2	0.0	0.0	931.3	69.8	286.0
221	1.0	TULE DES	49.6	76.0	62.8	6207.2	1603.7	3387.6	133.6	157.6	145.6	9.8	0.6	2.5	6217.0	1604.3	3390.1
222	2.0	VIRGIN R	32.0	108.0	70.0	15262.0	5153.4	10276.4	120.0	192.0	156.0	3300.8	333.5	1197.5	18562.7	5486.9	11474.0
223	3.0	GOLD BUTTE	96.0	132.0	114.0	11155.1	7587.9	9397.7	185.6	217.6	201.6	3008.1	1675.6	2271.3	14163.2	9363.5	11669.0

Table C-8. EFFECT INDEX OF BASING ALTERNATIVES ON GREAT BASIN VALLEYS

ALTERNATIVE NO 4
BASE A BERYL LONG TERM POP 16943.0
BASE B COYOTE LONG TERM POP 12195.0

LOCATION NO	APPL	NAME	MILES TO A N	MILES TO A F	MILES TO A AVE	EFFECT INDEX OF BASE A MAX	EFFECT INDEX OF BASE A MIN	EFFECT INDEX OF BASE A AVE	MILES TO B N	MILES TO B F	MILES TO B AVE	EFFECT INDEX OF BASE B MAX	EFFECT INDEX OF BASE B MIN	EFFECT INDEX OF BASE B AVE	COMBINED EFFECTS MAX	COMBINED EFFECTS MIN	COMBINED EFFECTS AVE
4	3.0	SNAKE	51.0	137.0	94.0	15057.8	7233.0	11349.0	132.0	225.0	178.5	5533.5	1227.7	2874.9	20591.3	8460.7	14223.9
5	1.0	PINE	18.0	62.0	40.0	14844.2	3525.5	8818.0	108.0	152.0	130.0	104.4	1.0	12.3	14948.6	3529.5	6830.3
6	2.0	WHITE	68.0	126.0	97.0	10570.0	3353.0	6486.7	158.0	214.0	186.0	954.7	113.9	357.3	11524.7	3466.9	6844.0
7	1.0	FISH SPR	108.0	154.0	131.0	145.0	1.1	15.4	198.0	245.0	221.5	0.0	0.0	0.0	145.0	1.1	15.4
8	1.0	DUGWAY	126.0	162.0	144.0	26.0	0.4	3.6	220.0	252.0	236.0	0.0	0.0	0.0	26.0	0.4	3.6
9	2.0	GOVT CRK	135.0	174.0	154.5	2638.4	771.4	1483.1	231.0	263.0	247.0	52.7	10.5	24.1	2691.0	781.9	1507.2
46	3.0	SEV DES	72.0	166.0	119.0	13393.3	4855.7	8914.1	171.0	263.0	217.0	3237.8	529.5	1441.2	16631.1	5385.1	10355.3
46A	1.0	SEV LAKE	54.0	105.0	79.5	5153.4	188.2	1284.2	154.0	195.0	174.5	0.8	0.0	0.0	5154.1	188.2	1284.3
50	1.0	MILFORD	28.0	71.0	49.5	12303.1	2164.7	6232.3	117.0	159.0	138.0	45.7	0.4	5.1	12348.8	2165.2	6237.5
53	3.0	BERYL-ENT	0.0	20.0	10.0	16943.0	16638.4	16866.3	77.0	119.0	98.0	9319.8	6416.1	7889.0	26262.8	23054.5	24755.3
54	1.0	WAH WAH	26.0	71.0	48.5	12857.6	2164.7	6486.7	123.0	163.0	143.0	25.4	0.2	2.9	12883.0	2165.0	6489.6
137A	2.0	BIG SMOKY	192.0	229.0	210.5	393.9	80.4	184.2	149.0	194.0	171.5	1265.7	262.0	606.4	1659.5	342.4	790.6
139	1.0	KOBEH	169.0	212.0	190.5	0.1	0.0	0.0	189.0	226.0	207.5	0.0	0.0	0.0	0.2	0.0	0.0
140	2.0	MONITOR	166.0	195.0	180.5	1018.1	349.9	609.8	151.0	203.0	177.0	1190.5	182.0	498.7	2208.7	531.8	1108.4
142	1.0	ALKALI SPR	188.0	206.0	197.0	0.0	0.0	0.0	134.0	157.0	145.5	8.0	0.5	2.2	8.0	0.5	2.2
149	1.0	STONE CBN	149.0	174.0	161.5	2.0	0.1	0.4	112.0	155.0	133.5	72.9	0.7	8.5	74.8	0.7	8.9
151	1.0	ANTELOPE	158.0	182.0	170.0	0.6	0.0	0.1	169.0	197.0	183.0	0.1	0.0	0.0	0.7	0.0	0.1
154	1.0	NEWARK	134.0	178.0	156.0	11.1	0.0	0.8	166.0	217.0	191.5	0.2	0.0	0.0	11.3	0.0	0.8
155	1.0	LITTLE SMO	135.0	165.0	150.0	10.0	0.3	1.7	118.0	188.0	153.0	41.5	0.0	0.9	51.5	0.3	2.6
156	2.0	HOT CRK	137.0	157.0	147.0	2495.9	1369.8	1868.0	105.0	163.0	134.0	3959.1	910.5	1951.9	6455.0	2180.3	3819.8
170	2.0	PENOYER	102.0	132.0	117.0	5860.4	2863.1	4191.3	65.0	95.0	80.0	7924.1	4855.5	6346.9	13784.5	7718.6	10538.2
171	1.0	COAL	75.0	100.0	87.5	1705.6	286.0	744.4	62.0	97.0	79.5	2539.7	262.0	924.3	4245.3	548.0	1668.9
172	2.0	GARDEN	89.0	112.0	100.5	7550.3	4710.8	6044.9	69.0	109.0	89.0	7502.3	3628.0	5434.5	15052.6	8338.8	11479.4
173	1.0	RAILROAD	98.0	149.0	123.5	336.2	2.0	33.5	83.0	171.0	127.0	732.9	0.1	16.9	1069.0	2.0	50.4
174	1.0	JAKES	118.0	142.0	130.0	57.6	4.5	17.1	155.0	186.0	170.5	0.7	0.0	0.1	58.3	4.5	17.2
175	1.0	LONG	138.0	169.0	153.5	7.1	0.1	1.1	178.0	232.0	205.0	0.0	0.0	0.0	7.2	0.1	1.1
178	1.0	BUTTE	129.0	194.0	161.5	19.0	0.0	0.4	178.0	254.0	216.0	0.0	0.0	0.0	19.0	0.0	0.4
179	2.0	STEPTOE	129.0	182.0	155.5	3101.2	576.9	1436.9	132.0	243.0	187.5	2060.7	29.5	337.4	5162.0	606.3	1774.3
180	2.0	CAVE	71.0	92.0	81.5	10129.7	7143.3	8602.7	97.0	138.0	117.5	4668.9	1746.8	2980.9	14798.6	8890.1	11583.6
181	1.0	DRY LAKE	49.0	69.0	59.0	6358.9	2426.8	4092.0	49.0	112.0	80.5	4576.9	72.9	865.9	10935.8	2499.7	4957.9
182	1.0	DELAMAR	63.0	83.0	73.0	3353.0	1018.2	1924.7	29.0	58.0	43.5	8651.7	3089.4	5633.2	12004.7	4107.5	7557.9
183	2.0	LAKE	45.0	83.0	64.0	13780.1	9388.8	11155.1	100.0	138.0	119.0	4395.7	1746.8	2874.9	18175.7	10135.5	14030.0
184	2.0	SPRING	49.0	151.0	100.0	13261.4	1654.0	6107.1	112.0	218.0	165.0	3390.7	95.5	758.0	16652.0	1749.6	6865.1
196	2.0	HAMLIN	11.0	75.0	43.0	16735.1	9543.6	14029.8	91.0	145.0	118.0	5238.5	1427.1	2945.3	21973.5	10970.7	16975.1
202	2.0	PATTERSON	35.0	60.0	47.5	14952.1	11734.2	13458.7	75.0	103.0	89.0	6869.2	4130.8	5434.5	21821.3	15865.0	18893.2
207	2.0	WHITERIVER	74.0	123.0	98.5	9589.9	3618.6	6275.5	89.0	169.0	129.0	5434.5	661.4	2232.1	15124.3	4280.0	8527.6
208	1.0	PAHROC	74.0	100.0	87.0	1812.6	286.0	771.4	22.0	66.0	44.0	10008.9	2060.7	5533.5	11821.5	2346.7	6304.9
209	1.0	PAHRANAGAT	74.0	100.0	87.0	1812.6	286.0	771.4	22.0	66.0	44.0	10008.9	2060.7	5533.5	11821.5	2346.7	6304.9
210	1.0	COYOTE	71.0	114.0	92.5	2164.7	34.2	515.6	0.0	31.0	15.5	12195.0	3238.2	11055.9	14359.7	3322.4	11571.5
141	1.0	RALSTON	171.0	194.0	182.5	0.1	0.0	0.0	123.0	168.0	145.5	25.4	0.1	2.2	25.5	0.1	2.2
3	2.0	DEEP CRK	132.0	164.0	148.0	2863.1	1089.1	1812.6	209.6	244.0	226.8	137.8	29.0	64.1	3000.9	1117.2	1876.7
47	2.0	HUNTINGTON	181.6	224.0	202.8	585.5	101.3	254.9	224.0	272.0	248.0	72.9	5.4	22.9	658.4	107.7	277.8
48	3.0	BEAVER	52.0	81.6	66.8	14987.6	12526.9	13838.9	149.6	180.0	164.8	4419.6	2805.7	3558.4	19407.2	15332.6	17397.4
49	2.0	PAROWAN	41.6	72.0	56.8	14200.4	9932.9	12190.4	129.6	168.0	148.8	2197.1	534.6	1273.4	16397.4	10667.5	13463.8
51	1.0	CEDAR CITY	28.0	52.0	40.0	12303.1	5619.2	8818.0	105.6	149.6	127.6	128.7	1.3	15.8	12431.8	5620.5	8833.8
52	1.0	LUND DIST	8.0	40.0	24.0	16506.1	8818.0	13393.3	104.0	140.0	122.0	147.5	4.1	28.0	16653.7	8822.1	13421.3
53	1.0	PINE(N)	196.0	237.6	216.8	0.0	0.0	0.0	224.0	277.6	250.8	0.0	0.0	0.0	0.0	0.0	0.0
54	1.0	CRESENT	224.0	248.0	236.0	0.0	0.0	0.0	249.6	280.0	264.8	0.0	0.0	0.0	0.0	0.0	0.0
55	1.0	CARICO L	224.0	248.0	236.0	0.0	0.0	0.0	236.0	272.0	254.0	0.0	0.0	0.0	0.0	0.0	0.0
56	2.0	UPPER REES	212.0	244.0	228.0	172.7	39.0	94.2	193.6	256.0	224.8	266.2	15.2	70.3	438.9	54.2	154.4
137B	2.0	BIG SMOKY	192.0	221.6	206.8	393.9	112.9	215.7	176.0	232.0	204.0	517.0	50.2	174.6	910.8	163.2	390.2
138	1.0	GRASS	208.0	232.0	220.0	0.0	0.0	0.0	220.0	253.6	236.8	0.0	0.0	0.0	0.0	0.0	0.0
150	1.0	LIT FISH L	160.0	176.0	168.0	0.5	0.1	0.2	153.6	181.6	167.6	0.9	0.0	0.1	1.3	0.1	0.3
153	1.0	DIAMOND	168.0	208.0	188.0	0.2	0.0	0.0	196.0	248.0	222.0	0.0	0.0	0.0	0.2	0.0	0.0
161	1.0	INDIAN SPR	124.0	165.6	144.8	31.9	0.2	3.3	37.6	65.6	51.6	5848.2	2105.5	4113.5	5880.0	2105.7	4116.7
169	1.0	TIKABOO S	100.0	120.0	110.0	286.0	47.5	121.4	8.0	41.6	24.8	11860.6	6017.5	9487.6	12166.6	6065.0	9609.0
176	3.0	RUBY	176.0	228.0	202.0	4158.1	1603.7	2662.7	224.0	288.0	256.0	1252.9	283.5	624.3	5411.0	1887.2	3287.0
185	1.0	TIPPETT	132.0	157.6	144.8	13.8	0.7	3.3	204.0	232.0	218.0	0.0	0.0	0.0	13.8	0.7	3.3
186	1.0	ANTELOPE	152.0	188.0	170.0	1.4	0.0	0.1	233.6	261.6	247.6	0.0	0.0	0.0	1.4	0.0	0.1
187	1.0	GOSHUTE	173.6	208.0	190.8	0.1	0.0	0.0	241.6	288.0	264.8	0.0	0.0	0.0	0.1	0.0	0.0
198	2.0	DRY	24.0	40.0	32.0	15975.9	14390.8	15262.0	80.0	96.0	88.0	6346.9	4761.8	5533.5	22322.8	19152.6	20795.5
201	3.0	SPRING	24.0	52.0	38.0	16506.1	14987.6	15869.0	96.0	116.0	106.0	8029.1	5624.5	7326.2	24535.2	21612.1	23195.2
205	2.0	MEADOW V	49.6	104.0	76.8	13181.5	5619.2	9281.2	8.0	64.0	36.0	12115.6	8029.1	10684.4	25297.2	13648.2	19965.6
206	1.0	KANE SPR	64.0	92.0	78.0	3183.6	535.0	1414.2	16.0	48.0	32.0	10985.1	4761.8	8029.1	14168.7	5297.1	9443.3
211	1.0	THREE LAK	121.6	160.0	140.8	40.5	0.5	5.2	20.0	60.0	40.0	10358.0	2905.7	6346.9	10398.6	2906.1	6352.1
215	3.0	BLACK MTNS	108.0	144.0	126.0	9992.9	6615.7	8247.0	36.0	60.0	48.0	11498.9	10358.0	10985.1	21481.8	16973.7	19232.1
216	2.0	GARNET	116.0	133.6	124.8	4292.2	2741.6	3457.6	16.0	36.0	26.0	11680.6	10684.4	11282.2	16172.7	13425.9	14839.7
217	2.0	HIDDEN V N	113.6	128.0	120.8	4540.4	3183.6	3822.1	16.0	28.0	22.0	11880.6	11257.4	11607.3	16421.0	14441.0	15429.5
218	2.0	CALIF WASH	104.0	132.0	118.0	5619.2	2863.1	4092.0	13.6	40.0	26.8	11967.0	10358.0	11333.2	17586.2	13221.1	15425.2
219	1.0	MUDDY R	17.6	112.0	64.8	14930.7	101.0	3052.5	8.0	16.0	12.0	11880.6	10985.1	11498.9	26811.3	11086.0	14551.4
220	1.0	LOWER MO	84.0	116.0	100.0	951.1	69.8	286.0	20.0	37.6	28.8	10358.0	6848.2	8692.7	11309.1	6917.9	8978.7
221	1.0	TULE DES	49.6	76.0	62.8	6207.2	1603.7	3387.6	33.6	56.0	44.8	7692.0	3290.7	5375.4	13899.5	4894.3	8763.0
222	2.0	VIRGIN R	32.0	108.0	70.0	15262.0	5153.4	10276.4	28.0	76.0	52.0	11257.4	6764.2	9254.5	26519.4	11917.5	19530.9
223	3.0	GOLD BUTTE	96.0	132.0	114.0	11155.1	7687.9	9397.7	40.0	68.0	54.0	11341.4	9868.0	10684.4	22496.5	17575.9	20082.1

Table C-9. EFFECT INDEX OF BASING ALTERNATIVES ON GREAT BASIN VALLEYS

ALTERNATIVE NO 9
BASE A: MILFORD LONG TERM POP 17221.0
BASE B: ELY LONG TERM POP 14347.0

LOCATION			MILES TO A			EFFECT INDEX OF BASE A			MILES TO B			EFFECT INDEX OF BASE B			COMBINED EFFECTS		
NO.	APPL	NAME	N	F	AVE	MAX	MIN	AVE	N	F	AVE	MAX	MIN	AVE	MAX	MIN	AVE
4	3.0	SNAKE	43.0	112.0	77.5	13839.8	9749.7	13114.7	25.0	89.0	57.0	13946.0	10017.3	12381.4	29781.9	19767.0	25496.1
5	1.0	PINE	25.0	51.0	38.0	13343.5	5956.6	9551.9	58.0	94.0	76.0	3634.5	389.5	1358.0	16978.0	6346.0	10909.9
6	2.0	WHITE	40.0	103.0	71.5	14626.9	5833.3	10221.3	60.0	85.0	72.5	9936.3	6864.0	8391.2	24563.2	12697.3	18612.5
7	1.0	FISH SPR	82.0	129.0	105.5	1107.0	19.3	183.3	85.0	108.0	96.5	751.7	122.8	320.7	1858.7	142.1	503.9
8	1.0	DUGWAY	98.0	132.0	115.0	341.7	14.0	77.9	100.0	122.0	111.0	242.2	33.0	93.9	583.9	47.0	171.8
9	2.0	GOVT CRK	103.0	143.0	123.0	5833.3	2137.2	3677.9	114.0	142.0	128.0	3809.2	1833.1	2695.8	9642.5	3970.3	6373.8
46	3.0	SEV DES	35.0	129.0	82.0	16290.4	8096.5	12694.7	82.0	155.0	118.5	10576.1	4825.8	7589.0	26866.5	12922.3	20283.8
46A	1.0	SEV LAKE	23.0	77.0	50.0	13876.7	1531.3	6207.3	75.0	103.0	89.0	1444.3	188.9	565.8	15321.0	1720.2	6773.1
50	1.0	MILFORD	0.0	20.0	10.0	17221.0	14626.9	16532.3	91.0	169.0	130.0	488.5	0.1	14.5	17709.5	14627.1	16546.7
53	3.0	BERYL-ENT	23.0	80.0	51.5	16812.8	12882.6	15269.3	83.0	180.0	131.5	10497.3	3300.8	6549.0	27310.0	16183.4	21818.3
54	1.0	WAH WAH	9.0	49.0	29.0	16661.0	6463.2	12217.4	69.0	100.0	84.5	2055.0	242.2	778.1	18716.0	6705.4	12995.6
137A	2.0	BIG SMOKY	211.0	258.0	234.5	183.3	19.3	63.0	123.0	183.0	153.0	3064.1	470.6	1316.4	3247.4	489.9	1379.3
139	1.0	KOBEH	178.0	215.0	196.5	0.0	0.0	0.0	72.0	109.0	90.5	1729.1	112.4	506.9	1729.2	112.4	506.9
140	2.0	MONITOR	186.0	209.0	197.5	504.6	199.7	321.7	85.0	118.0	101.5	6864.0	3465.0	5014.3	7368.6	3664.7	5336.0
142	1.0	ALKALI SPR	218.0	235.0	226.5	0.0	0.0	0.0	149.0	168.0	158.5	1.7	0.1	0.5	1.7	0.1	0.5
149	1.0	STONE CBN	177.0	206.0	191.5	0.0	0.0	0.0	98.0	145.0	121.5	284.7	2.7	34.7	284.7	2.7	34.7
151	1.0	ANTELOPE	172.0	194.0	183.0	0.1	0.0	0.0	68.0	89.0	78.5	2173.2	365.8	1159.9	2173.3	365.8	1159.9
154	1.0	NEWARK	142.0	180.0	161.0	4.6	0.0	0.4	34.0	74.0	54.0	8950.5	1534.9	4363.8	8955.0	1534.9	4364.2
155	1.0	LITTLE SMO	148.0	175.0	161.5	2.3	0.1	0.4	49.0	88.0	68.5	5384.6	608.2	2113.5	5386.8	608.2	2113.9
156	2.0	HOT CRK	160.0	186.0	173.0	1263.5	504.6	812.3	71.0	120.0	95.5	8577.6	3300.8	5657.1	9841.1	3805.3	6469.4
170	2.0	PENOYER	134.0	168.0	151.0	2756.3	966.7	1681.2	88.0	129.0	108.5	6510.0	2626.0	4315.8	9266.3	3592.7	5997.0
171	1.0	COAL	106.0	134.0	120.0	175.5	11.3	48.2	66.0	105.0	85.5	2424.4	159.4	726.0	2599.9	170.7	774.2
172	2.0	GARDEN	117.0	142.0	129.5	4260.1	2200.3	3110.8	63.0	102.0	82.5	9569.1	4962.5	7163.7	13829.2	7162.8	10274.5
173	1.0	RAILROAD	118.0	178.0	148.0	58.6	0.0	2.3	29.0	126.0	77.5	10178.5	22.0	1236.2	10237.1	22.0	1238.4
174	1.0	JAMES	123.0	145.0	134.0	35.8	3.2	11.3	15.0	37.0	26.0	13088.1	8205.2	10887.6	13123.9	8208.4	10898.9
175	1.0	LONG	142.0	171.0	156.5	4.6	0.1	0.8	34.0	75.0	54.5	8950.5	1444.3	4268.2	8955.0	1444.4	4269.0
178	1.0	BUTTE	129.0	185.0	157.0	19.3	0.0	0.7	23.0	97.0	60.0	11560.8	308.2	3300.8	11580.2	308.3	3301.5
179	2.0	STEPTOE	92.0	171.0	131.5	7260.6	871.4	2949.4	0.0	85.0	42.5	14347.0	6864.0	11932.1	21607.6	7735.4	14881.5
180	2.0	CAVE	86.0	103.0	94.5	8096.5	5833.3	6923.2	20.0	62.0	41.0	13773.2	9692.0	12085.5	21869.7	15525.2	19008.8
181	1.0	DRY LAKE	80.0	108.0	94.0	1263.5	147.4	467.5	46.0	109.0	77.5	6048.8	112.4	1236.2	7312.3	259.8	1703.6
182	1.0	DELAMAR	100.0	120.0	110.0	290.7	48.2	123.4	100.0	129.0	114.5	242.2	16.1	68.0	532.9	64.4	191.4
183	2.0	LAKE	63.0	92.0	77.5	11486.0	7260.6	9330.1	25.0	68.0	46.5	13460.6	8950.5	11506.4	24946.6	16211.0	20836.5
184	2.0	SPRING	62.0	142.0	102.0	11633.5	2200.3	5956.6	9.0	64.0	36.5	14228.9	9445.9	12523.4	25862.4	11646.2	18480.0
196	2.0	HAMLIN	37.0	75.0	56.0	14975.8	9700.2	12505.0	34.0	95.0	64.5	12750.6	5712.3	9384.2	27726.4	15412.5	21889.2
202	2.0	PATTERSON	62.0	85.0	73.5	11633.5	8239.0	9923.2	58.0	91.0	74.5	10178.5	5162.9	8143.2	21811.9	14401.9	18066.5
207	2.0	WHITERIVER	97.0	135.0	116.0	6593.1	2681.7	4362.6	5.0	72.0	38.5	14310.4	8453.3	12333.2	20903.6	11135.0	16695.6
208	1.0	PAHROC	108.0	138.0	123.0	147.4	7.2	35.8	97.0	138.0	117.5	308.2	6.0	51.2	455.6	13.3	87.0
209	1.0	PAHRANAGAT	108.0	138.0	123.0	147.4	7.2	35.8	97.0	138.0	117.5	308.2	6.0	51.2	455.6	13.3	87.0
210	1.0	COYOTE	123.0	180.0	151.5	35.8	0.0	1.5	132.0	243.0	187.5	11.7	0.0	0.0	47.5	0.0	1.5
141	1.0	RALSTON	194.0	222.0	208.0	0.0	0.0	0.0	112.0	157.0	134.5	85.7	0.6	8.9	85.7	0.6	8.9
3	2.0	DEEP CRK	117.6	149.6	133.6	4199.3	1754.9	2786.6	60.0	89.6	74.8	9936.3	6323.9	8106.1	14135.6	8078.9	10892.7
47	2.0	HUNTINGTON	181.6	220.0	200.8	395.1	123.4	281.3	72.0	116.0	94.0	8453.3	3634.5	5823.5	9048.4	3757.9	6104.9
48	3.0	BEAVER	17.6	48.0	32.8	16980.8	15512.4	16400.9	125.6	152.0	138.8	7015.4	5031.6	5988.4	23996.2	20544.0	22389.3
49	2.0	PAROWAN	24.0	44.0	34.0	16438.0	14133.9	15304.9	136.0	156.0	146.0	2173.2	1197.5	1629.8	18611.2	15331.5	16934.6
51	1.0	CEDAR CITY	16.0	49.6	32.8	15512.4	6309.0	11100.7	128.0	156.0	142.0	17.9	0.7	3.8	15530.3	6309.7	11104.6
52	1.0	LUND DIST	12.0	48.0	30.0	16238.0	6724.3	11926.7	93.6	140.0	116.8	401.6	4.8	54.8	16639.6	6729.1	11981.5
53	1.0	PINE(N)	200.0	236.0	218.0	0.0	0.0	0.0	88.0	128.0	108.0	608.2	17.9	122.8	608.2	17.9	122.8
54	1.0	CRESENT	228.0	236.0	232.0	0.0	0.0	0.0	116.0	141.6	128.8	59.1	4.0	16.4	59.1	4.0	16.4
55	1.0	CARICO L	233.6	253.6	243.6	0.0	0.0	0.0	121.6	140.0	130.8	34.3	4.8	13.3	34.3	4.8	13.3
56	2.0	UPPER REES	232.0	253.6	242.8	70.9	24.3	42.3	125.6	152.0	138.8	2868.6	1358.0	2009.1	2939.5	1382.3	2051.1
137B	2.0	BIG SMOKY	212.0	237.6	224.8	175.5	54.2	99.2	108.0	141.6	124.9	4363.8	1854.4	2927.8	4539.3	1908.6	3027.0
138	1.0	GRASS	217.6	240.0	228.8	0.0	0.0	0.0	105.6	125.6	115.6	151.4	22.9	61.4	151.4	22.9	61.4
150	1.0	LIT FISH L	180.0	196.0	188.0	0.0	0.0	0.0	80.0	104.0	92.0	1052.6	173.6	453.3	1052.7	173.6	453.3
153	1.0	DIAMOND	173.6	212.0	192.8	0.1	0.0	0.0	61.6	97.6	79.6	3048.8	293.9	1080.4	3048.9	293.9	1080.4
161	1.0	INDIAN SPR	160.0	204.0	182.0	0.5	0.0	0.0	153.6	205.6	179.6	0.9	0.0	0.0	1.4	0.0	0.1
169	1.0	TIKABOO S	137.6	157.6	147.6	7.6	0.7	2.4	136.0	176.0	156.0	7.6	0.0	0.7	15.1	0.7	3.1
176	3.0	RUBY	176.0	216.0	196.0	4226.3	2075.5	3015.9	65.6	124.0	94.8	11803.3	7143.6	9544.5	16029.6	9219.1	12560.4
185	1.0	TIPPETT	120.0	144.0	132.0	48.2	3.6	14.0	45.6	73.6	59.6	6140.0	1572.3	3365.8	6188.2	1575.9	3379.9
186	1.0	ANTELOPE	141.6	172.0	156.8	4.8	0.1	0.9	68.0	100.0	84.0	2173.2	242.2	805.4	2178.0	242.3	806.1
187	1.0	GOSHUTE	161.6	204.0	182.8	0.4	0.0	0.0	77.6	128.0	102.8	1228.4	17.9	192.1	1228.8	17.9	192.1
198	2.0	DRY	56.0	73.6	64.8	12505.0	9908.4	11219.5	92.0	104.0	98.0	6048.8	4758.2	5384.6	18553.9	14666.5	16604.1
201	3.0	SPRING	52.0	68.0	60.0	15233.5	13963.2	14626.9	64.0	93.6	78.8	11914.8	9642.9	10825.8	27148.3	23606.1	25452.[illegible]
205	2.0	MEADOW V	88.0	140.0	114.0	7814.1	2330.6	4572.3	109.6	177.6	143.6	4211.5	574.1	1749.6	12025.5	2904.7	6321.8
206	1.0	KANE SPR	101.6	128.0	114.8	254.8	21.5	79.4	124.0	152.0	138.0	27.0	1.2	6.0	281.8	22.6	85.5
211	1.0	THREE LAK	160.0	197.6	178.8	0.5	0.0	0.0	173.6	205.6	189.6	0.1	0.0	0.0	0.6	0.0	0.0
215	3.0	BLACK MTNS	141.6	180.0	160.8	6936.6	3962.3	5330.8	189.6	209.6	199.6	2810.2	1956.5	2355.4	9746.7	5918.5	7686.2
216	2.0	GARNET	152.0	169.6	160.8	1630.0	914.9	1230.8	181.6	201.6	191.6	495.8	226.8	338.8	2125.8	1141.7	1569.6
217	2.0	HIDDEN V N	152.0	164.0	158.0	1630.0	1107.0	1348.2	181.6	192.0	186.8	495.8	333.5	407.8	2125.8	1440.5	1756.0
218	2.0	CALIF WASH	140.0	165.6	152.8	2330.6	1049.0	1589.9	176.0	204.0	190.0	608.2	205.4	360.5	2938.8	1254.3	1950.5
219	1.0	MUDDY R	136.0	149.6	142.8	9.1	1.9	4.2	165.6	177.6	171.6	0.2	0.0	0.1	9.3	1.9	4.3
220	1.0	LOWER MO	121.6	152.0	136.8	41.2	1.4	8.3	165.6	193.6	179.6	0.2	0.0	0.0	41.4	1.4	8.3
221	1.0	TULE DES	88.0	112.0	100.0	730.0	102.9	290.7	133.6	157.6	145.6	9.8	0.6	2.5	739.9	103.5	293.2
222	2.0	VIRGIN R	68.0	141.6	104.8	10743.4	2225.9	5614.8	120.0	192.0	156.0	3300.8	333.5	1197.5	14044.2	2559.4	6812.4
223	3.0	GOLD BUTTE	128.0	164.0	146.0	9191.5	5085.3	6549.7	185.6	217.6	201.6	3008.1	1675.6	2271.3	12199.5	6760.9	8821.0

Table C-10. EFFECT INDEX OF BASING ALTERNATIVES ON GREAT BASIN VALLEYS

ALTERNATIVE NO. 6
BASE A MILFORD LONG TERM POP 17221.0
BASE B COYOTE LONG TERM POP 12195.0

LOCATION			MILES TO A			EFFECT INDEX OF BASE A			MILES TO B			EFFECT INDEX OF BASE B			COMBINED EFFECTS		
NO	APPL	NAME	N	F	AVE	MAX	MIN	AVE	N	F	AVE	MAX	MIN	AVE	MAX	MIN	AVE
4	3.0	SNAKE	43.0	112.0	77.5	15935.3	9749.7	13114.7	132.0	225.0	178.5	5533.5	1227.7	2874.9	21369.3	10977.4	15989.7
5	1.0	PINE	25.0	51.0	38.0	13343.5	5956.6	9551.9	108.0	152.0	130.0	104.4	1.0	12.3	13447.9	5957.6	9564.2
6	2.0	WHITE	40.0	103.0	71.5	14626.9	5833.3	10221.3	158.0	214.0	186.0	954.7	113.9	357.3	15581.7	5947.2	10578.6
7	1.0	FISH SPR	82.0	129.0	105.5	1107.0	19.3	183.3	198.0	245.0	221.5	0.0	0.0	0.0	1107.0	19.3	183.3
8	1.0	DUGWAY	98.0	132.0	115.0	341.7	14.0	77.9	220.0	252.0	236.0	0.0	0.0	0.0	341.7	14.0	77.9
9	2.0	GOVT CRK	103.0	143.0	123.0	5833.3	2137.2	3677.9	231.0	263.0	247.0	52.7	10.5	24.1	5885.9	2147.7	3702.1
46	3.0	SEV DES	35.0	129.0	82.0	16290.4	8096.5	12694.7	171.0	263.0	217.0	3237.8	529.5	1441.2	19528.2	8626.0	14135.9
46A	1.0	SEV LAKE	23.0	77.0	50.0	13876.7	1531.3	6207.3	154.0	195.0	174.5	0.8	0.0	0.0	13877.5	1531.3	6207.3
50	1.0	MILFORD	0.0	20.0	10.0	17221.0	14626.9	16532.3	117.0	159.0	138.0	45.7	0.4	5.1	17266.7	14627.3	16537.4
53	3.0	BERYL-ENT	23.0	80.0	51.5	16812.9	12982.6	15269.3	77.0	119.0	98.0	9319.8	6416.1	7889.0	26132.5	19298.7	23158.3
54	1.0	WAH WAH	9.0	49.0	29.0	16661.0	6463.2	12217.4	123.0	163.0	143.0	25.4	0.2	2.9	16686.3	6463.5	12220.3
137A	2.0	BIG SMOKY	211.0	258.0	234.5	183.3	19.3	63.0	149.0	194.0	171.5	1265.7	262.0	606.4	1449.0	281.3	669.4
139	1.0	KOBEH	178.0	215.0	196.5	0.0	0.0	0.0	189.0	226.0	207.5	0.0	0.0	0.0	0.0	0.0	0.0
140	2.0	MONITOR	186.0	209.0	197.5	504.6	199.7	321.7	151.0	203.0	177.0	1190.5	182.0	498.7	1695.1	381.6	820.4
42	1.0	ALKALI SPR	218.0	235.0	226.5	0.0	0.0	0.0	134.0	157.0	145.5	8.0	0.5	2.2	8.0	0.5	2.2
149	1.0	STONE CBN	177.0	206.0	191.5	0.0	0.0	0.0	112.0	155.0	133.5	72.9	0.7	8.5	72.9	0.7	8.5
151	1.0	ANTELOPE	172.0	194.0	183.0	0.1	0.0	0.0	169.0	197.0	183.0	0.1	0.0	0.0	0.2	0.0	0.0
154	1.0	NEWARK	142.0	180.0	161.0	4.6	0.0	0.4	166.0	217.0	191.5	0.2	0.0	0.0	4.7	0.0	0.4
155	1.0	LITTLE SMO	148.0	175.0	161.5	2.3	0.1	0.4	118.0	188.0	153.0	41.5	0.0	0.9	43.7	0.1	1.3
156	2.0	HOT CRK	160.0	186.0	173.0	1263.5	504.6	912.3	105.0	163.0	134.0	3959.1	810.5	1951.9	5222.6	1315.1	2764.2
170	2.0	PENOYER	134.0	168.0	151.0	2756.3	966.7	1681.2	65.0	95.0	80.0	7924.1	4855.5	6346.9	10680.3	5822.2	8029.1
171	1.0	COAL	106.0	134.0	120.0	175.5	11.3	48.2	62.0	97.0	79.5	2539.7	262.0	924.3	2715.2	273.3	972.6
172	2.0	GARDEN	117.0	142.0	129.5	4260.1	2200.3	3110.8	69.0	109.0	89.0	7502.3	3628.0	5434.5	11762.4	5828.3	8545.3
173	1.0	RAILROAD	118.0	178.0	148.0	58.6	0.0	2.3	83.0	171.0	127.0	732.9	0.1	16.9	791.4	0.1	19.1
174	1.0	JAKES	123.0	145.0	134.0	35.8	3.2	11.3	155.0	186.0	170.5	0.7	0.0	0.1	36.5	3.2	11.4
175	1.0	LONG	142.0	171.0	156.5	4.6	0.1	0.8	178.0	232.0	205.0	0.0	0.0	0.0	4.6	0.1	0.8
178	1.0	BUTTE	129.0	185.0	157.0	19.3	0.0	0.7	178.0	254.0	216.0	0.0	0.0	0.0	19.4	0.0	0.7
179	2.0	STEPTOE	92.0	171.0	131.5	7260.6	871.4	2949.4	132.0	243.0	187.5	2060.7	29.5	337.4	9321.3	900.9	3286.9
180	2.0	CAVE	86.0	103.0	94.5	8096.5	5833.3	6923.2	97.0	138.0	117.5	4668.9	1746.8	2980.9	12765.4	7580.0	9904.1
181	1.0	DRY LAKE	80.0	108.0	94.0	1263.5	147.4	467.5	49.0	112.0	80.5	4576.9	72.9	865.9	5840.4	220.3	1333.4
182	1.0	DELAMAR	100.0	120.0	110.0	290.7	48.2	123.4	29.0	58.0	43.5	8651.7	3089.4	5633.2	8942.4	3137.6	5756.6
183	2.0	LAKE	63.0	92.0	77.5	11486.0	7260.6	9330.1	100.0	138.0	119.0	4395.7	1746.8	2874.9	15881.7	9007.3	12205.0
184	2.0	SPRING	62.0	142.0	102.0	11633.5	2200.3	5956.6	112.0	218.0	165.0	3390.7	95.5	758.0	15024.1	2295.8	6714.6
196	2.0	HAMLIN	37.0	75.0	56.0	14975.8	9700.2	12505.0	91.0	145.0	118.0	5238.5	1427.1	2945.3	20214.3	11127.3	15450.3
202	2.0	PATTERSON	62.0	85.0	73.5	11633.5	8239.0	9923.2	75.0	103.0	89.0	6869.2	4130.8	5434.5	18502.6	12369.9	15357.7
207	2.0	WHITERIVER	97.0	135.0	116.0	6593.1	2681.7	4362.6	89.0	169.0	129.0	5434.5	661.4	2232.1	12027.6	3343.1	6594.7
208	1.0	PAHROC	108.0	138.0	123.0	147.4	7.2	35.8	22.0	66.0	44.0	10008.9	2060.7	5533.5	10156.3	2068.0	5569.3
209	1.0	PAHRANAGAT	108.0	138.0	123.0	147.4	7.2	35.8	22.0	66.0	44.0	10008.9	2060.7	5533.5	10156.3	2068.0	5569.3
210	1.0	COYOTE	123.0	180.0	151.5	35.8	0.0	1.5	0.0	31.0	15.5	12195.0	8238.2	11055.9	12230.8	8238.2	11057.4
141	1.0	RALSTON	194.0	222.0	208.0	0.0	0.0	0.0	123.0	168.0	145.5	25.4	0.1	2.2	25.4	0.1	2.2
3	2.0	DEEP CRK	117.6	149.6	133.6	4199.3	1754.9	2786.6	209.6	244.0	226.8	137.8	28.0	64.1	4337.2	1783.0	2850.6
47	2.0	HUNTINGTON	181.6	220.0	200.8	595.1	123.4	281.3	224.0	272.0	248.0	72.9	6.4	22.9	668.0	129.8	304.3
48	3.0	BEAVER	17.6	48.0	32.8	16980.8	15512.4	16400.9	149.6	180.0	164.8	4419.6	2805.7	3558.4	21400.4	18318.1	19959.4
49	2.0	PAROWAN	24.0	44.0	34.0	16238.0	14133.9	15304.9	129.6	168.0	148.8	2197.1	684.6	1273.4	18435.1	14818.5	16578.3
51	1.0	CEDAR CITY	16.0	49.6	32.8	15512.4	6309.0	11100.7	105.6	149.6	127.6	128.7	1.3	15.8	15641.1	6310.3	11116.6
52	1.0	LUND DIST	12.0	48.0	30.0	16238.0	6724.3	11926.7	104.0	140.0	122.0	147.5	4.1	28.0	16385.5	6728.3	11954.9
53	1.0	PINE(N)	200.0	236.0	218.0	0.0	0.0	0.0	224.0	277.6	250.8	0.0	0.0	0.0	0.0	0.0	0.0
54	1.0	CRESENT	228.0	236.0	232.0	0.0	0.0	0.0	249.6	280.0	264.8	0.0	0.0	0.0	0.0	0.0	0.0
55	1.0	CARICO L	233.6	253.6	243.6	0.0	0.0	0.0	236.0	272.0	254.0	0.0	0.0	0.0	0.0	0.0	0.0
56	2.0	UPPER REES	232.0	253.6	242.8	70.9	24.3	42.0	193.6	256.0	224.8	266.2	15.2	70.3	337.1	39.5	112.3
137B	2.0	BIG SMOKY	212.0	237.6	224.8	175.5	54.2	99.2	176.0	232.0	204.0	517.0	50.2	174.6	692.5	104.5	273.8
138	1.0	GRASS	217.6	240.0	228.8	0.0	0.0	0.0	220.0	253.6	236.8	0.0	0.0	0.0	0.0	0.0	0.0
150	1.0	LIT FISH L	180.0	196.0	188.0	0.0	0.0	0.0	153.6	181.6	167.6	0.8	0.0	0.1	0.8	0.0	0.1
153	1.0	DIAMOND	173.6	212.0	192.8	0.1	0.0	0.0	196.0	248.0	222.0	0.0	0.0	0.0	0.1	0.0	0.0
161	1.0	INDIAN SPR	160.0	204.0	182.0	0.5	0.0	0.0	37.6	65.6	51.6	6848.2	2105.5	4113.5	6848.7	2105.5	4113.5
169	1.0	TIKABOO S	137.6	157.6	147.6	7.6	0.7	2.4	8.0	41.6	24.8	11880.6	6017.5	9487.6	11888.1	6018.2	9490.0
176	3.0	RUBY	176.0	216.0	196.0	4226.3	2075.5	3015.9	224.0	288.0	256.0	1252.9	283.5	624.3	5479.2	2359.0	3640.2
185	1.0	TIPPETT	120.0	144.0	132.0	48.2	3.6	14.0	204.0	232.0	218.0	0.0	0.0	0.0	48.2	3.6	14.0
186	1.0	ANTELOPE	141.6	172.0	156.8	4.8	0.1	0.8	233.6	261.6	247.6	0.0	0.0	0.0	4.9	0.1	0.8
187	1.0	GOSHUTE	161.6	204.0	182.8	3.4	0.0	0.0	241.6	288.0	264.8	0.0	0.0	0.0	3.4	0.0	0.0
198	2.0	DRY	56.0	73.6	64.8	12505.0	9908.4	11219.5	90.0	96.0	98.0	6346.9	4761.8	5533.5	18851.9	14670.1	16753.0
201	3.0	SPRING	52.0	68.0	60.0	15233.5	13963.2	14626.9	96.0	116.0	106.0	8029.1	6624.5	7326.2	23262.6	20587.7	21953.1
205	2.0	MEADOW V	88.0	140.0	114.0	7814.1	2330.6	4572.3	8.0	64.0	36.0	12115.6	8029.1	10684.4	19929.7	10359.7	15256.6
206	1.0	KANE SPR	101.6	128.0	114.8	254.8	21.5	79.4	16.0	48.0	32.0	10985.1	4761.8	8029.1	11239.9	4783.2	8108.5
211	1.0	THREE LAK	160.0	197.6	178.8	0.5	0.0	0.0	20.0	60.0	40.0	10358.0	2805.7	6346.9	10358.5	2805.7	6346.9
215	3.0	BLACK MTNS	141.6	180.0	160.8	6936.6	3962.0	5330.8	36.0	60.0	48.0	11498.9	10358.0	10985.1	18435.5	14320.3	16315.8
216	2.0	GARNET	152.0	169.6	160.8	1630.0	914.9	1230.8	16.0	36.0	26.0	11880.6	10684.4	11382.2	13510.6	11599.2	12613.0
217	2.0	HIDDEN V N	152.0	164.0	158.0	1630.0	1107.0	1348.2	16.0	28.0	22.0	11880.6	11257.4	11607.3	13510.6	12364.4	12955.6
218	2.0	CALIF WASH	140.0	165.6	152.8	2330.6	1049.0	1589.9	13.6	40.0	26.8	11967.0	10358.0	11333.2	14297.6	11407.0	12923.1
219	1.0	MUDDY R	136.0	149.6	142.8	9.1	1.9	4.2	8.0	16.0	12.0	11880.6	10985.1	11498.9	11889.6	10986.9	11503.1
220	1.0	LOWER MO	121.6	152.0	136.8	41.2	1.4	9.3	20.0	37.6	28.8	10358.0	6848.2	9692.7	10399.2	6849.5	8701.0
221	1.0	TULE DES	88.0	112.0	100.0	730.3	102.9	290.7	33.6	56.0	44.8	7692.3	3390.7	5375.4	8422.4	3493.6	5666.1
222	2.0	VIRGIN R	68.0	141.6	104.8	10743.4	2225.9	5614.8	28.0	76.0	52.0	11257.4	6764.2	9254.5	22000.8	8990.0	14869.3
223	3.0	GOLD BUTTE	128.0	164.0	146.0	8191.5	5085.3	6549.7	40.0	68.0	54.0	11341.4	9888.0	10684.4	19532.9	14973.3	17234.1

Table C-11. COMBINED AVERAGE EFFECT INDICES OF BASING ALTERNATIVES ON GREAT BASIN VALLEYS

LOCATION NO	NAME	APPEAL	AVERAGE EFFECT INDEX BY ALTERNATIVE 0	1	2	3	4	5	6
4	SNAKE	3 0	13718 4	12360 8	15629 7	23730 4	14223 9	25496 1	15989 7
5	PINE	1 0	7266 2	6695 6	1920 8	10175 0	8833 3	10909 9	9564 2
6	WHITE	2 0	8225 9	5381 4	12239 5	14877 9	5844 0	18612 5	10578 6
7	FISH SPR	1 0	129 1	11 7	5344 4	336 0	15 4	503 9	183 3
8	DUGWAY	1 0	39 2	2 7	2133 9	97 5	3 6	171 8	77 9
9	GOVT CRK	2 0	2823 2	1155 0	9964 6	4178 9	1507 2	6373 8	2702 1
46	SEV DES	3 0	11522 4	6609 2	14906 8	16303 1	10355 3	20283 8	14139 9
46A	SEV LAKE	1 0	4711 5	372 8	10599 1	1850 0	1284 3	6773 1	6207 3
50	MILFORD	1 0	12555 0	4727 6	386 0	6246 8	6237 5	16546 7	16537 4
53	BERYL-ENT	3 0	21918 6	23105 1	17526 0	23415 3	24755 3	21818 3	23158 0
54	WAH WAH	1 0	9277 0	4917 0	4073 3	7264 8	6489 5	12995 6	12220 3
57A	BIG SMOKY	2 0	341 8	933 5	317 2	1500 6	790 6	1379 3	569 4
136	ADDEH	1 0	0 0	3 1	0 0	506 9	0 0	506 9	0 0
140	MONITOR	2 0	897 1	1114 3	883 8	5624 1	1108 4	5336 0	820 4
142	ALKALI SPR	1 0	2 8	2 5	2 8	0 5	2 2	0 5	2 2
149	STONE CBN	1 0	11 1	11 4	11 1	35 1	8 9	34 7	8 5
151	ANTELOPE	1 0	0 0	0 1	0 1	1160 0	0 1	1159 9	0 0
154	NEWARK	1 0	0 0	0 5	0 2	4364 6	0 8	4364 2	0 4
155	LITTLE SMO	1 0	1 4	2 4	1 4	2115 2	2 6	2113 9	1 0
156	HOT CRK	2 0	3172 1	3975 5	2934 1	7525 0	3819 8	6469 4	2764 2
170	PENOYER	2 0	9586 1	11484 9	8718 5	8507 2	10538 2	5997 0	8023 1
171	COAL	1 0	1246 9	1774 1	1210 9	1470 4	1668 9	776 2	972 6
172	GARDEN	2 0	9476 5	11694 0	8275 3	10208 6	11479 4	10274 5	8545 0
173	RAILROAD	1 0	23 8	47 5	22 2	1269 7	50 4	1238 4	19 1
174	JAKES	1 0	8 7	13 1	33 2	10904 7	17 2	10898 9	11 4
175	LONG	1 0	0 6	0 9	11 8	4269 0	1 1	4269 0	0 8
178	BUTTE	1 0	0 6	0 0	31 5	3301 2	0 4	3301 5	0 7
179	STEPTOE	2 0	2660 5	1530 2	4798 1	13369 0	1774 0	14881 5	3286 9
180	CAVE	2 0	9157 7	10419 3	7749 8	20688 2	11583 6	19008 8	9904 1
181	DRY LAKE	1 0	1488 6	4233 4	1150 8	3328 2	4957 9	1703 5	1333 4
182	DELAMAR	1 0	7469 2	8833 5	7375 9	1992 7	7557 9	191 4	5756 6
183	LAKE	2 0	10845 9	12213 9	8545 0	22661 5	14030 3	20836 5	12205 0
184	SPRING	2 0	5513 6	5618 5	7937 9	16630 4	6865 1	18480 0	6714 6
196	HAMLIN	2 0	13347 8	14483 6	10344 1	23413 9	16975 1	21689 2	15450 3
202	PATTERSON	2 0	14647 3	17310 1	10747 2	21601 9	19893 2	18066 5	15357 7
207	WHITERIVER	2 0	6233 8	7691 0	5771 3	18628 6	8527 6	16695 8	6594 7
208	PAHROC	1 0	7272 3	7829 4	7245 2	322 6	6304 9	37 0	5569 3
209	PAHRANAGAT	1 0	7272 3	7829 4	7245 2	822 6	6304 9	37 0	5569 3
210	COYOTE	1 0	14476 7	14866 1	14475 6	315 6	11571 5	1 5	11057 4
141	RALSTON	1 0	2 8	2 8	2 8	9 9	2 2	8 9	2 2
3	DEEP CRK	2 0	2198 9	1456 9	6425 0	9918 7	1876 7	10892 7	2850 6
47	HUNTINGTON	2 0	243 6	223 1	535 4	6078 4	277 3	6104 9	304 3
48	BEAVER	3 0	17107 7	15141 8	15330 0	19827 0	17397 4	22389 3	19959 4
49	PANGWAN	2 0	13283 9	10901 3	6719 3	13820 1	13463 8	16934 6	16578 3
51	CEDAR CITY	1 0	9446 4	5700 2	1308 9	3821 8	8833 8	11104 6	11116 6
52	LUND DIST	1 0	9089 3	10181 9	176 1	13448 0	13421 3	11981 5	11954 8
53	PINE(N)	1 0	0 0	0 0	0 0	122 8	0 0	122 8	0 0
54	CRESENT	1 0	0 0	0 0	0 0	16 4	0 0	16 4	0 0
55	CARICO L	1 0	0 0	0 0	0 0	13 3	0 0	13 3	0 0
56	UPPER REES	2 0	123 9	159 8	116 7	2093 3	154 4	2051 1	112 3
57B	BIG SMOKY	2 0	303 9	391 9	273 3	3143 5	390 2	3027 0	273 6
58	GRASS	1 0	0 0	0 0	0 0	61 4	0 0	61 4	0 0
150	LIT FISH L	1 0	0 2	0 0	0 2	453 5	0 0	453 3	0 1
153	DIAMOND	1 0	0 0	0 0	0 0	1080 4	0 0	1080 4	0 0
161	INDIAN SPR	1 0	5385 8	5388 3	5385 8	3 3	4116 7	0 1	4113 5
169	TIKABOO S	1 0	12424 0	12514 2	12422 2	122 1	9609 0	0 1	9490 0
76	RUBY	3 0	3106 5	2834 0	5252 0	12207 2	3287 0	12560 4	3640 2
185	TIPPETT	1 0	10 7	2 5	371 3	3369 1	3 3	3379 9	14 1
186	ANTELOPE	1 0	0 6	0 1	98 0	805 5	0 1	806 1	0 5
187	JOSHUTE	1 0	0 0	0 0	8 2	192 1	0 1	192 1	0 0
196	DRY	2 0	15760 9	18805 7	9815 4	20646 6	20795 5	16604 1	16753 0
201	SPRING	3 0	20694 3	21612 7	17210 9	26694 8	23195 2	25452 7	21953 1
205	MEADOW V	2 0	17459 5	21019 5	14408 5	11030 8	19965 5	6321 8	15256 6
206	KANE SPR	1 0	10573 8	11583 8	10512 5	1420 0	9443 0	85 5	8108 5
211	THREE LAK	1 0	8310 1	8314 0	8310 0	5 2	6352 1	0 0	6346 9
215	BLACK MTNS	3 0	18429 9	20629 8	15430 9	10602 5	19232 1	7686 2	16315 6
216	GARNET	2 0	15837 0	17521 8	14952 0	3796 3	14839 7	1569 6	12613 0
217	HIDDEN V N	2 0	16220 9	19092 9	15255 0	4229 9	15429 5	1756 0	12955 6
218	CALIF WASH	2 0	16045 4	17938 3	14997 9	4452 6	15425 2	1950 5	12923 1
219	MUDDY R	1 0	15058 8	17367 8	15055 6	2052 6	14551 4	4 0	11503 1
220	LOWER MO	1 0	11387 7	11598 0	11381 4	286 0	8979 7	9 3	8701 0
221	TULE DES	1 0	7258 6	9604 3	7038 1	3390 1	8763 0	293 2	5666 1
222	VIRGIN R	2 0	16379 7	19901 2	12618 4	11474 0	19530 9	6812 4	14869 3
223	GOLD BUTTE	3 0	18960 4	21107 7	15405 9	11669 3	20082 1	8821 0	17234 1

APPENDIX D

HUMAN IMPACT AND WILD HORSE BIOLOGY

INTRODUCTION

Land management agencies have paid little attention to the ecological role of some species within the Great Basin Desert. Although many recent studies have documented that species incurring reductions in habitat availability also experience declining population levels, the single or combined effects of habitat alteration on demography remains vague or unknown. In this report, various aspects of the biology of wild (feral) horses (Equus caballus) in areas of potential M-X deployment are projected based on 3 years of data collected on insular populations within the Great Basin.

ASSUMPTIONS, BIOLOGICAL BASELINE CONDITIONS, AND IMPACT PROJECTIONS

Prior studies of animal conservation have emphasized cause and effect relationships involved with the responses of individuals to disturbances. Multidisciplinary approaches have included topics as diverse as competition theory, bioenergetics, distributional patterns, adaptive trends, human aesthetics, and economic rewards. Except for those latter two topics, each of which involve political judgments, the prior four are based on principles of natural selection. Therefore, they are predicated on Mendelian genetics and patterns of differential gene survival over several (or many) generations. A biological approach based on genetic inheritance to study environmental impact appears sound because: 1) it is widely accepted among contemporary scientists; 2) it explains best the population biology of most species; and 3) once baseline patterns are established, it can be used for impact prediction.

In biological evolution, as in the economic world, perpetuating entities are considered end ("ultimate") products simply because they are or recently have been successful. The proximate mechanisms leading to such products are of interest because they can be viewed as a means of evaluating and/or predicting the success of such products.

For purposes of conservation and impact prediction, the demographic response of a species can be viewed as an end product and, as such, it is the most important item in terms of biological "currency." Stated simply, reproduction equals success. Species capable of sustained or increased reproductive output are winners since their populations will not experience local extirpations.

For most species, logistic difficulties preclude in-depth studies of the effects of specific intrusions or the demographic responses of a species. Consequently, extrapolations are made as to the: 1) projected long-term effects on a population; or 2) the responses of other populations based on the study animals. In other words, extrapolations are common among scientists given that other factors are equal. In this report, predictions concerning the long-term effects of M-X OB sites (specifically those at Beryl/Milford) on horses are made using demographic, behavioral, and ecological data from four study sites within the Great Basin Desert.

METHODS

Feral horses were studied in a number of areas within, contiguous to, and outside the M-X deployment area. Sites for long-term study (i.e., areas censused three or more times periodically for at least two years) included: the Granite Range (Washoe County), Fox Mountain (Washoe County), Division Peak (Washoe County), and the Lava Beds/Seven Troughs Range (Pershing County). Sites studied for briefer periods included: Stone Cabin and Ralston Valleys (Nye County), the Needle Range (Beaver County), and Pine Valley (Beaver County). These latter two sites are located in Utah.

A 20-60X spotting scope was used for field observations of individual animals and groups throughout the year over a three year period. Social and maintenance behaviors, object flight distance, gaits, and distance traveled were observed and recorded. A stop watch was used for timing animal activities.

RESULTS AND DISCUSSION

Study Areas

To determine the effects of varying disturbances upon horses, it was necessary first to establish a study site with minimal or no disturbances so that subsequent perturbations would be better understood. Thus, the three-year intensive study concentrated on horses within the Granite Range. Once baseline data on natural grouping patterns, mating systems, foraging mechanics, and reproductive rates were established, it was then possible to determine the influence of extrinsic disturbances upon behavioral and demographic responses. Briefer surveys of other horse populations in adjacent or potential M-X deployment areas varying in disturbance history and proximity to human settlements were made to compare various aspects of wild horse biology.

A brief synopsis and categorization of each horse population and its disturbance history follows. They are ranked in order from minimal to maximum disturbance (i.e., Area I, II, etc.). In certain cases, when it was not possible to rank areas as more or less disturbed than others, the areas were ranked equally.

Area I: No disturbances/Pristine = Granite Range

Area II: Road Disturbances = Needle Range, Ralston Valley, Fox Mountain

Area III: Some shooting and roundups = Division Peak, Lava Beds

Area IV: Major disturbances = Stone Cabin Valley

Area I. The Granite Range was the only site within this rating. From June 1979 until July 1981 only three vehicles gained access to the study site and this was accomplished only after dynamite blasted a path through a rock-strewn road. Recreationists, photographers, hunters, and other forms of human disturbance did not exceed two parties per year. Field work in this area was performed exclusively by backpacking.

Area II. The Needle Range, upper hills of eastern Ralston Valley, and Fox Mountain are accessible by poor quality dirt roads. During winters they may average one vehicle per month whereas summer traffic averages about six vehicles per month. Only during the hunting and trapping season does vehicular use exceed 30 vehicles per week. Roads through horse habitat in the Needle Range receive about 50 percent of the above figures based on estimates of HDR field crews.

Area III. The Division Peak, Lava Beds, and Seven Troughs Range areas have been the focal points of roundups by local government agencies in recent years. Reports from local inhabitants indicate that harassment, in the form of "wrangling," shooting, and chasing of horses, has occurred in the past and continues at present. Estimated vehicular usage in these areas is indicated in Table D-1.

Area IV. Stone Cabin Valley has been the source of most major and documented disturbances of horses. BLM personnel indicate roundups of horses have occurred for the past 30 years. Additionally, shooting, hunting, trapping, and ORV use occur within habitats utilized by horses and provide further disturbance. Vehicular usage within this area could not be estimated.

Behavior: Overt Responses

The responses of horses to sonic booms, high flying and low flying (less than 500 ft) aircraft, vehicles on roads, and humans on foot were noted at varying study sites. Many vagaries in stimulus-response occurred, and the data should be viewed tentatively. For example, it was not always possible to fly over or approach (on the ground) animals in a standardized fashion. However, the data suggest that those populations with more disturbance in a historical sense tend to exert more energy in avoiding humans than do those for which harassment is less common (Figures D-1 through D-3).

Mating Systems and Mate Choice

In all populations studied, horses were organized into distinct social groupings. Those included bands of one or more stallions and their respective harems (females and young). Males not obtaining harems remained solitary or they joined other males, an association designated as a bachelor group. Males attempted to appropriate as many females as were economically defendable. Evidence suggests that females show mating preferences for individual stallions. It is, therefore, important to understand how human intrusions affect natural social groupings and, subsequently, whether reproductive rates are influenced.

In the Granite Range population, natural bands were occasionally split for short periods of time due to the presence of human observers. Furthermore, members of groups familiar with one another experience less aggression and forage more efficiently than do individuals in newly formed bands. In the latter, chances of reproductive failure (pre- and postnatal losses) are greater for the following reasons. Newly formed bands (especially those led by young, inexperienced, yet adult bachelors) inhabit peripheral home ranges or those having inferior food quality throughout the winter; consequently, the chances for increased prenatal mortality are greater than in more firmly established bands.

In the Granites, at least two bands newly formed in 1980 and 1981 inhabited less than optimal home ranges. The most dramatic example of this occurred during the winter of 1980/1981 when a newly formed band spent the entire winter in wind-

Table D-1. Estimated vehicular usage within selected horse habitats in the Great Basin Desert (vehicle/month).

Season	Area I	Area II	Area III	Area IV
Spring/Summer	0.3	6	10	NA[1]
Fall	0.3	20	30	40++
Winter	0	1	2	NA

T6066/10-2-81

[1]NA = not available.

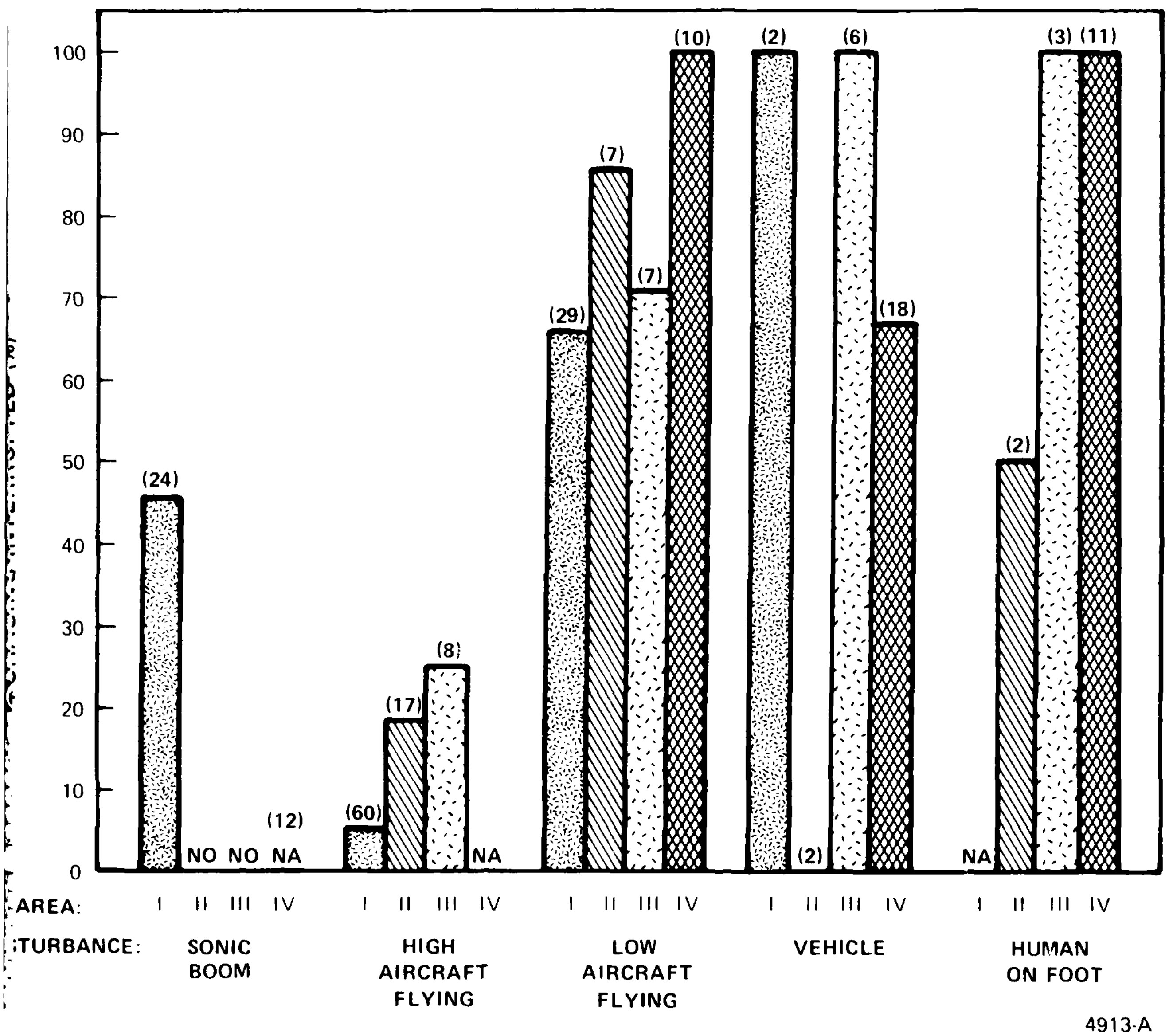

Figure D-1. Foraging response of wild horses to disturbance. Level of disturbance increased from a minimum in Area I to a maximum in Area IV. (NO = not observed, NA = not available, and numbers in parentheses are sample size.)

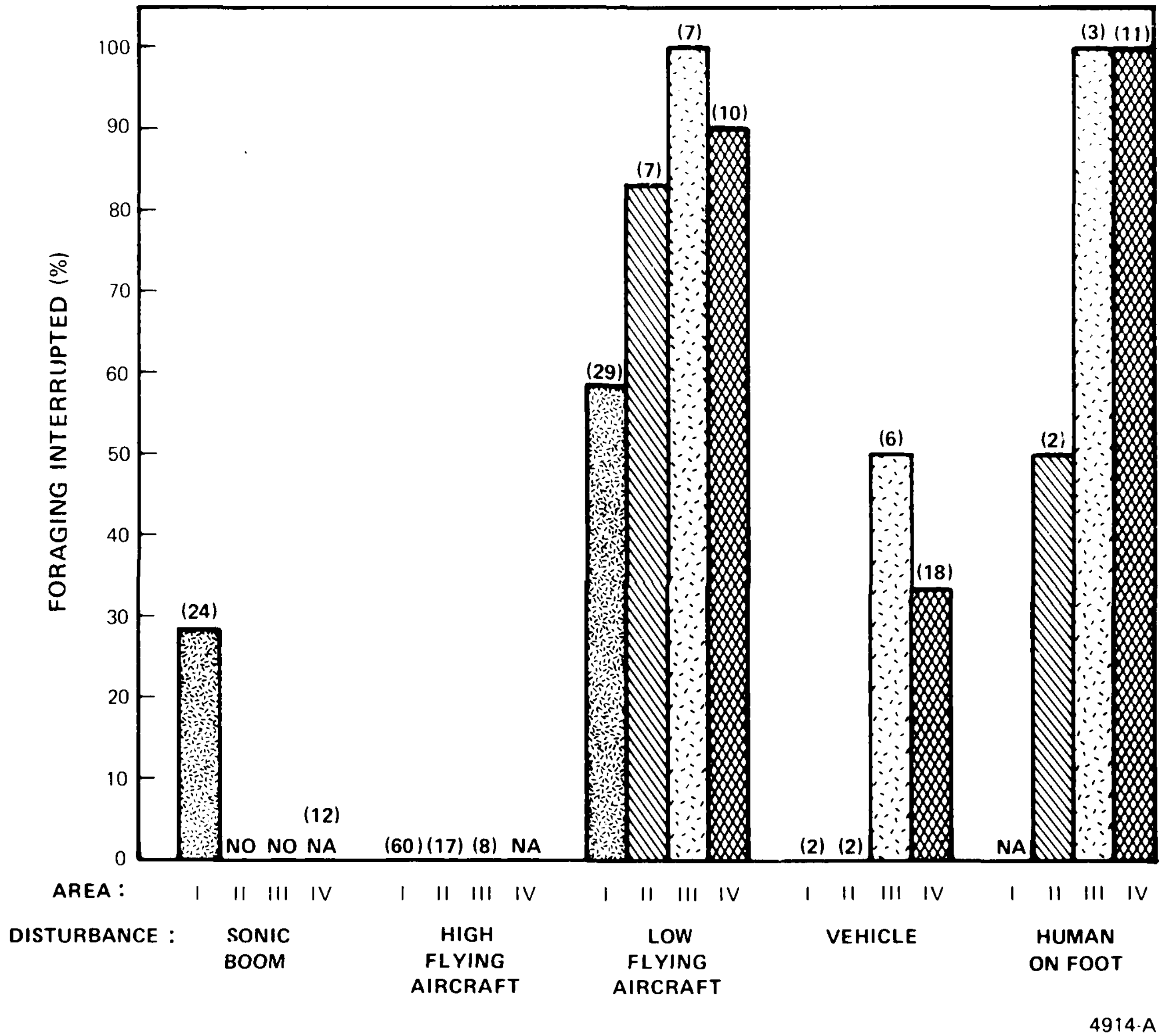

Figure D-2. Flight response of wild horses to disturbance (no. of times flight occurred ÷ no. of times foraging interrupted x 100). Level of disturbance increased from a minimum in Area I to a maximum in Area IV. (NO = not observed, NA = not available, and numbers in parentheses are sample size.)

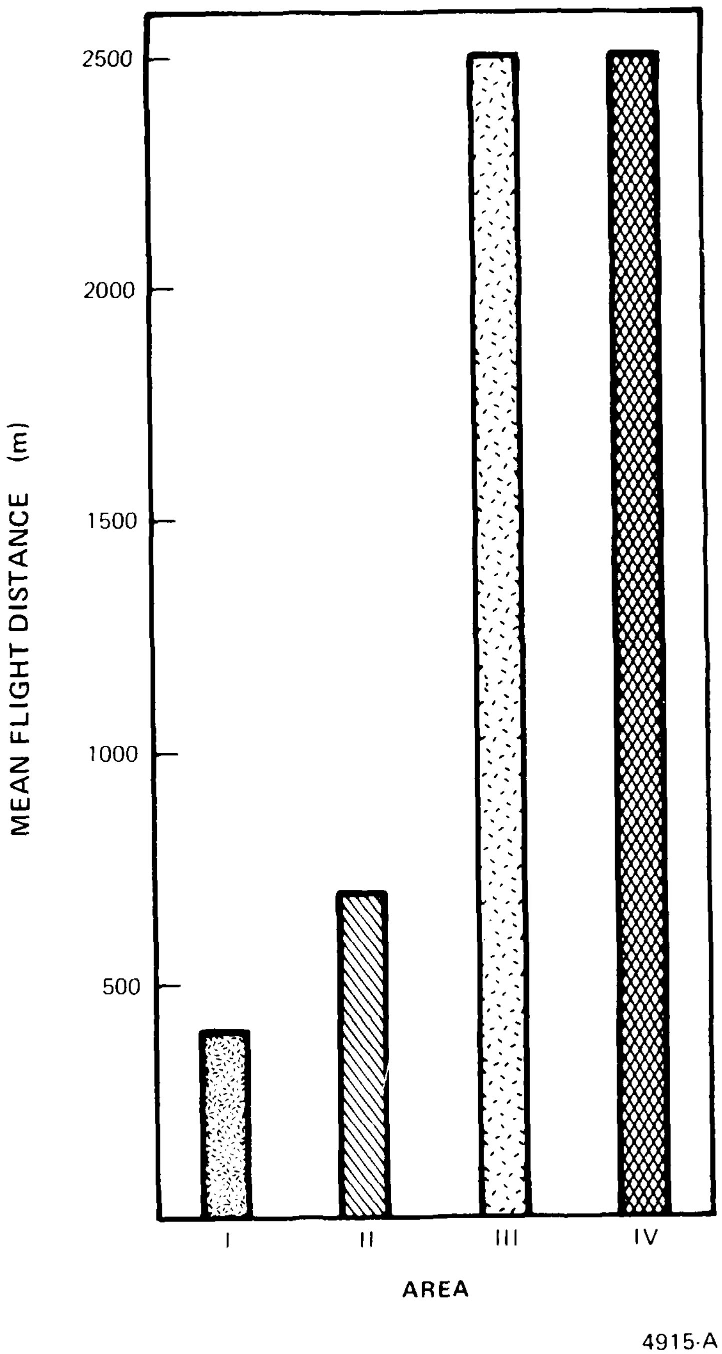

Figure D-3. Mean flight distance for wild horses approached to within 70 m by humans on foot. Level of disturbance increased from a minimum in Area I to a maximum in Area IV.

exposed areas with little shelter, all above 7,000 ft, while the remaining bands were in more protected basins at 5,000 ft. Mortality occurred in the high altitude group. Thus, some data are suggestive that mortality can result from changes in band composition, and it is likely that normal mating and/or grouping patterns can be interrupted with deleterious effects if entry into wild horse habitat occurs without caution.

Foraging Ecology

Theory and previous data (Berger et al., in press) predict that animals maximize their energy intake by foraging with few interruptions. Individuals feeding most efficiently should convert the energy accrued into reproductive effort (i.e., fetal growth, milk production, etc.) rather than body maintenance. Previous studies (Berger et al., in press and literature therein) indicated that pronghorn in disturbed environments interrupted foraging more frequently, for greater periods of time, and overexploited food patches more often than did undisturbed populations, simply because the former were more vigilant due to a history of past disturbance.

For horses, there are no a priori reasons to believe that the time-energy budgets of foraging animals would not also vary in accordance with disturbance history. However, contrary to the above hypothesis, our data reflect no clear differences in the time-energy budgets of foraging horses (Table D-2). In other words, horses in Stone Cabin Valley (the most disturbed environment) did not appear to interrupt foraging for surveillance activities any more than did horses in other areas. It seems likely that feral horses are not as vigilant as native North American ungulates--possibly because natural predators are few. They thereby do not fit the prediction that increased vigilance responses occur in accordance with disturbance history. It is plausible that the fact that horses have been domesticated for thousands of years accounts for their low vigilance rates, even in areas of disturbance.

Demography, Natural Patterns

Data are not yet available to understand the extent to which food resource quality, abundance, and distribution affect reproduction in horses. Without such information it is not possible to determine or separate the confounding variables influencing feral horse demography. For example, if two populations, "A" and "B", have identical recruitment rates (i.e., 50 percent of the adult females produce foals annually and the survival rate is 90 percent), it still would not be possible to know whether "A" did so because food was abundant while "B" did so because females incurred energy debits in relation to factors associated with disturbance. Many other vagaries could be superimposed on this simple example as well. The only valid conclusion that could be reached based on existing evidence is that recruitment rates are similar. The underlying causes, whether reflecting true biological trends or reflecting human disturbance, could not be known. Given the above problem in interpreting the mechanisms responsible for demographic rates, the following statements should be accepted as tentative only.

The Granite Range has the greatest animal productivity (Table D-3) and has averaged about 0.9 foals per mare annually, while the two more disturbed sites have experienced recruitment rates of about 0.3 foals per mare per year. However, the conclusion that disturbance has reduced annual productivity due to increased energy expenditure by females seems unwarranted for at least three major reasons.

Table D-2. Average number of minutes per 10 minute foraging bout spent in surveillance by gravid mares.

Study Site			
Granite Range		Stone Cabin Valley	
Sample Size	Surveillance Time[1]	Sample Size	Surveillance Time[1]
66	0.18	8	0.25

T6067/10-2-81

[1]Differences in surveillance time were not significant at the 95 percent confidence level (p greater than 0.05) using the t-test.

Table D-3. Foal to mare ratios in selected geographical areas.

Date of Census	Area I	Area II	Area III	Area IV
Summer 1980				
Number of Adult Females	26	--	NA[1]	27
Foal/Mare Ratio	0.88	--	NA	0.29
Summer 1981				
Number of Adult Females	29	24	NA	NA
Foal/Mare Ratio	0.86	0.33	NA	NA

T6068/10-2-81

[1]NA = not available.

First, the Granite Range has more altitudinal relief and topographical diversity than the habitats of other populations studied. Since the Granites exceed 9,000 ft, horses have opportunities to migrate altitudinally, exploit heterogeneous environments, and avoid biting insects.

Second, the Granite Range horses have greater opportunities to exploit richer food bases than other populations because the former feed on high altitude bunch grasses. In contrast, Stone Cabin Valley horses probably have a much more limited food supply since few opportunities for altitudinal migration exist. Furthermore, in late fall, the available grasses in Stone Cabin Valley become leached and increase in lignification, resulting in less digestible energy for horses. Stone Cabin Valley horses are unable to follow plant phenological sequences like Granite Range horses can.

Third, competition with domestic livestock does not occur in the Granites whereas all other study sites have at least periodic seasonal competitors. In summary, it appears that food competition rather than disturbance histories may be the most significant factor contributing to differences in demography between horse populations. Corroborative data supporting this trend were presented in Table D-2 where differences in surveillance rates were not detected.

Domestication

Hafez (1968) described general adaptive trends in domesticated mammals. In essence, the processes of natural selection have been altered by man to provide for durable animals capable of subsistence (at some times) under arduous and primitive conditions. Since horses are large-bodied generalist herbivores, they tend to be more resilient than native large mammals, and they persist under a wide range of environmental conditions extending from the Yukon Territories to Mexico. Although horses evolved as grazers they subsist on a varied diet (e.g., browse in the Grand Canyon). Horses do not appear as susceptible to disturbances as native species and become habituated much more easily. It seems likely that horses will not be impacted by construction and other M-X related activities to the same level as native wildlife provided that laws pertaining to protection from shooting, chasing, and other harassment are strictly enforced.

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